A STUDY OF THE ECONOMIC AND ENVIRONMENTAL IMPACTS OF GOVERNMENT-ASSISTED LAND DRAINAGE IN ONTARIO

by

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VERN SPENCER

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A Report to the

Select Committee on Land Drainage

of the

Ontario Legislature

Department of Geography

York University

Downsview, Ontario

September 15, 1973

SUMMARY

This study concerns the full benefits and costs associated with agricultural land drainage which is supported financially by the Government of Ontario. It considers not only agricultural benefits but also impacts on the natural environment. The creation of special land-use conflicts resulting from drain construction, particularly in wetlands and along the rural-urban fringe, is also examined. In general, the study addresses the questions of whether drainage projects have been worthwhile and whether any modifications in current procedures could be devised to avoid problems in the future.

The study begins with a township-by-township overview of drainage expenditures during the period 1964-72 under The Drainage Act and The Tile Drainage Act. Based on total expenditures as well as recent charges, seven distinctive regions are identified: Southwestern Ontario, the Southwestern Ontario Fringe, Southern Georgian Bay, Eastern Ontario, Niagara, North Shore of Lake Ontario, and Northern Ontario.

Following a theoretical survey the study proceeds to an examination of evidence gathered at a number of field locations across the Province. The research is centred on seven townships (Brooke, Caldwell, Cumberland, Ellice, Mersea, Ramsay, and West Luther), as well as other selected sites. Within the townships a representative sample of 37 drainage projects, completed within the period 1965-70, are systematically analysed. Special land-use conflicts are examined in detail at the Martin drain (Brant County), the Stroud Swamp (Simcoe County), and on the outskirts of the City of

Niagara Falls.

It is concluded that, on the whole, drainage projects have led to good agricultural benefits at the local scale without creating undue damage to the environment or serious land-use conflicts. Yet a significant and large minority of projects have not generated enough agricultural benefits to justify their construction. Considerable variation in the benefit-cost balance is evident between drains, and there is a tendency for the traditional centre of farming activity, Southwestern Ontario, to experience the most beneficial responses. Environmental impacts at the local scale normally involve minor impacts on natural ecosystems and stream hydrology. In some cases considerable destruction of woodlots and wetlands is evident, which is particularly significant in Southwestern Ontario where wetlands are scarce and where acreages under cultivation are expanding. The area north of Toronto is also experiencing a significant destruction of wetlands, which is likely to become more crucial as urbanization proceeds.

The analysis of land-use conflicts in wetlands and the rural-urban fringe indicates that good evidence of serious cases is rather rare. On the other hand, legitimate cases of conflict between individuals and groups have been identified, and it is concluded that procedures currently in practice do not facilitate effective resolution.

The accurate measurement of many large-scale impacts of drainage is beyond the scope of this study. For example, the influences which drainage activity exert on general food price levels and on large watershed hydrology would require much more research before conclusions could be reached.

The study concludes by suggesting ways in which problems relating to land drainage could be overcome by alternative types of legislation. It is indicated that many problems could be avoided through an initial assessment of potential impacts of drainage projects. It is also concluded that comprehensive evaluations of projects are extremely difficult in the absence of Province-wide, or at least region-wide, rural land-use objectives or priorities.

ACKNOWLEDGMENTS

Many people, far more than can be mentioned here, have contributed to the completion of this study.* To all of them the authors extend sincere appreciation. A special "thank you" is directed to Dr. D. B. Freeman, one of our colleagues, who began as part of the research team but was later required to leave in order to join the field team of the York University Kenya Project. Thanks are also extended to Dr. J. C. Day and Professor B. Bucknall, special consultants to the project; and to Mrs. Heather Clarke, Paul McCague, Bryan Kelner, and Geoff Kettel, the research assistants. The staff of the Geography Department of York University, particularly the Cartography office and Mrs. Florence Maybee, have been of great assistance throughout the project. Our deep appreciation is extended to them and to the staff of the York University Secretarial Services who prepared the manuscript.

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*Appendix 1 is, hopefully, a complete list of the persons who have assisted with the study.

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Chapter 1

INTRODUCTION

1.1 Terms of Reference

The research project outlined in this report, which was undertaken for the Ontario Legislature's Select Committee on Land Drainage during the period January 1 to September 15, 1973, concerns three of the topics indicated in the terms of reference for the Select Committee*:

(1) the associated problems of competing land use in the urban fringe and in wetlands, as influenced by drainage projects [in Ontario];

(2) the problem of public interest in land use over the drainage of private land by individuals;

(3) the prior evaluation of the benefits and costs of a drainage project.

The three topics are by no means independent of each other or of most of the other topics under consideration by the Select Committee. So the project's research design involves a general investigation of Government-assisted land drainage in Ontario, together with specific analyses of the "full" benefits and costs associated with drainage, and of situations arising from competing uses for land. The final objective of the project is to suggest alternatives or modifications to the current Drainage Act (Revised Statutes of Ontario, 1970, Chapter 136 as amended by 1972, Chapter 1, Section 7) to alleviate problems identified in the research.

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*Items two, three and four on the Select Committee's list of eleven topics for investigation.

1.2 Research Design

Research for the project was designed to fall into four distinct phases, the complete details of which are described throughout the remainder of the report:

Phase One--Inventory and Hypothesis Formulation

The period January 1 through to mid-March was used to compile information about the extent, costs, and impacts of agricultural drains using existing data. Primary emphasis was placed on preparing an overview of drainage activity in Ontario, although reports from other areas, particularly those concerning the environmental impacts of drain construction, were analysed. From this inventory the researchers were able to understand more fully the pattern of drainage activity in Ontario, to conceptualize the situations under which drains have been constructed, and to hypothesize the kinds of impacts and relationships that drainage would be expected to have at the local and province-wide scales. Phase one, then, provided the necessary background information and conceptual base for the remainder of the research.

Phase Two--Selection of Sites for Detailed Study

Phase two, which occupied the period mid-March to mid-May, was used to select specific field situations for anlysis and to develop methodologies for undertaking those investigations. The field sites were of two types: (1) a sample of seven townships distributed across the province within which drain-level surveys were to be undertaken. This sample was designed to provide fairly "typical" province-wide coverage, as well as allowing for the investigation of several broadly-defined problems. (2) Specific sites where special problems, particularly those related to land-use competition, had been identified. These sites represented in no way a random selection, but rather particular problem areas. A number of research methodologies

were developed during phase two, the most significant being the fomulation and testing of a standard farm-level questionnaire.

Phase Three--Field Investigations

Phase three occupied most of the period from mid-May to mid-August. Activity centred on the completion of the property-level questionnaires and on the analysis of special sites where land-use conflicts were evident.

Phase Four--Evaluation of Results and Preparation of Final Report

The final stage of the project, which terminated on September 15, was devoted to the analysis of questionnaire and other data, the determination of conclusions, and writing.

1.3 Organization of the Remainder of the Report

The following chapters describe in detail the various procedures and findings of the four stages of research. The overview of drainage activity in Ontario, on which much of the work in phase two is based, is presented in Chapter 2. Chapter 3 describes the picture of drainage impacts and relationships at two scales which emerged following the survey of the Ontario situation as well as descriptions of sites out of the province. Chapter 3 is strongly conceptual or theoretical, tracing the kinds of drainage impacts which are expected on the basis of considerable scientific but limited empirical inputs. As such, it points to the kinds of data that are required for confirmation in the real world, some of which can be gathered easily, and some of which are impossible to obtain in the short run. In short, Chapter 3 provides the framework against which the surveys described in later chapters were undertaken. Chapter 4 describes the technical details concerning the ways in which regions, drains, and properties were selected for analysis, the kinds of data obtained, and the methods used for analysis. Chapter 5

describes the "agricultural" benefits and costs associated with sample drains, and Chapter 6 reports findings on the "environmental" impacts of drain construction. Chapter 7 presents an analysis of situations where drainage projects have given rise to conflicts between different types of land users. Chapter 8 presents the researchers' suggestions for alternatives to the current land drainage legislation, and Chapter 9 provides for final conclusions and reflections.

Chapter 2

AN OVERVIEW OF DRAINAGE EXPENDITURES IN ONTARIO, 1964-72

2.1 Introduction

As a part of phase one of this project, the inventory and hypothesis formulation phase, the researchers undertook an overview of expenditures on government assisted land drainage projects for the period of 1964-72. The aim of this overview was to provide background information on both the magnitude and regional distribution of drainage activity.

The basic data sets employed in the overview were the Government of Ontario records of expenditures in the form of grants to municipalities under The Drainage Act, and in the form of debenture purchases under The Tile Drainage Act. The data were compiled at the township level and were presented in a series of maps for expenditures in the southern part of the province and in tables for expenditures in the northern part of the province.

This chapter includes four major sections. The first section is a summary of the various government programmes which have provided assistance for land drainage during the period 1964-72. The second and third sections detail the regional patterns of government expenditures under The Drainage Act and The Tile Drainage Act, respectively. In the final section, a discussion of the regional patterns of drainage activity is presented.

2.2 Government Assistance Programmes for Land Drainage During the Period 1964-72

Government assistance programmes for the drainage of agricultural land under The Drainage Act and The Tile Drainage Act were in effect

throughout the 1964-72 period. In addition to the above continuing programmes, several other programmes of supplementary assistance were made available for shorter periods of time. The supplementary programmes included special grants under A.R.D.A. and from the Ministry of Agriculture and Food. Each of the drainage assistance programmes is discussed below.

(a) The Drainage Act. The Drainage Act of 1962-63 (S.O. 1962-63 Chapter 39) as amended up to 1970 and as revised in 1972 (R.S.O. 1972 Chapter 139), provides for provincial government grants to assist the construction of municipal drainage works on agricultural lands. This act provides for the payment of grants amounting to 33 1/3 percent of the cost of drainage works constructed in a county, 66 2/3 percent of the cost of drainage works constructed in a territorial district or a provisional county, and up to 80 percent of the cost of drainage works constructed in a territory without municipal organization. The above grant programme was available throughout the 1964-72 period.

(b) The Tile Drainage Act. The Tile Drainage Act of 1960 (R.S.O. 1960 Chapter 399) as amended up to 1970 and as revised in 1971 (S.O. 1971 Chapter 37) provides for assistance in the construction of on-farm tile drainage. Assistance under this act is in the form of provincial government purchases of low-interest debentures from municipalities so as to enable municipalities to loan land-owners up to 75 percent of the cost of tile drainage. These loans are at low-interest rates and are to be paid back over a ten-year period. This assistance for tile drainage was available throughout the 1964-72 period.

(c) A.R.D.A. Drainage Assistance. Under the federal-provincial A.R.D.A. programme additional assistance has been made available for municipal drainage work for agricultural land. Commencing on April 1, 1966 the

A.R.D.A. branch of the Ontario Department of Agriculture and Food made available a grant of 33 1/3 percent in addition to the grants under The Drainage Act for drainage works constructed in the eleven counties of Eastern Ontario. On January 1, 1967 this grant programme was extended to include all of the counties in Southern Ontario. This programme continued until December 31, 1968 when it was cancelled due to a lack of funds. Since January, 1968 A.R.D.A. drainage grants have only been available in the eleven counties of Eastern Ontario.

A special case relating to the A.R.D.A. grants for municipal drainage applies to projects in parts of nine townships; West Luther, Proton, East Luther, Arthur, Egremont, Amaranth, Melancthon, Artemesia, and Osprey; in the counties of Grey, Dufferin and Wellington. This area was the subject of a special A.R.D.A. study of drainage in the Micro-drainage area which is the source of several major river systems. This study was not completed until late in 1968. When the A.R.D.A. Drainage assistance programme was cancelled at the end of 1968, the municipalities located within the Micro-drainage study area requested an extension of the A.R.D.A. assistance on the basis of their claim that they had not been able to fully utilize the programme prior to the completion of the Micro-drainage Study. Their request was granted and A.R.D.A. grants of 33 1/3 percent of the cost of drainage works were made available in this area for projects petitioned after April 1, 1971 and for which engineers were appointed prior to March 31, 1973.

(d) Special Agricultural Drainage Assistance. When the A.R.D.A. assistance programme was suddenly cancelled at the end of 1968 for most of Southern Ontario, many municipalities were in the process of

initiating projects which had been petitioned by farmers expecting the A.R.D.A. grant. In June 1969 the Ontario Department of Agriculture and Food undertook to pay an additional grant of 33 1/3 percent on all drainage works petitioned prior to the termination of the A.R.D.A. programme but which were constructed too late to qualify for assistance under that programme. In effect, this special assistance meant that all drainage projects petitioned after April 1966 and before December 1968 were eligible either for the ARDA grant or the Special Assistance Grant of 33 1/3 percent in addition to The Drainage Act grant of 33 1/3 percent.

(e) Capital Grants for Farm Development Programme. In April 1967 the provincial government introduced the Capital Grants for Farm Development Programme. This programme provided for grants of 33 1/3 percent of the cost of drainage or permanent agricultural structures up to a maximum of \$1000 per farmer. In 1971 the rate of assistance under this programme was increased to 40 percent up to a maximum of \$3000 per farmer. Under this programme it is possible for a farmer to obtain a grant towards the cost of tile drainage on his farm.

2.3 Grant Expenditures Under the Drainage Act, 1964-72

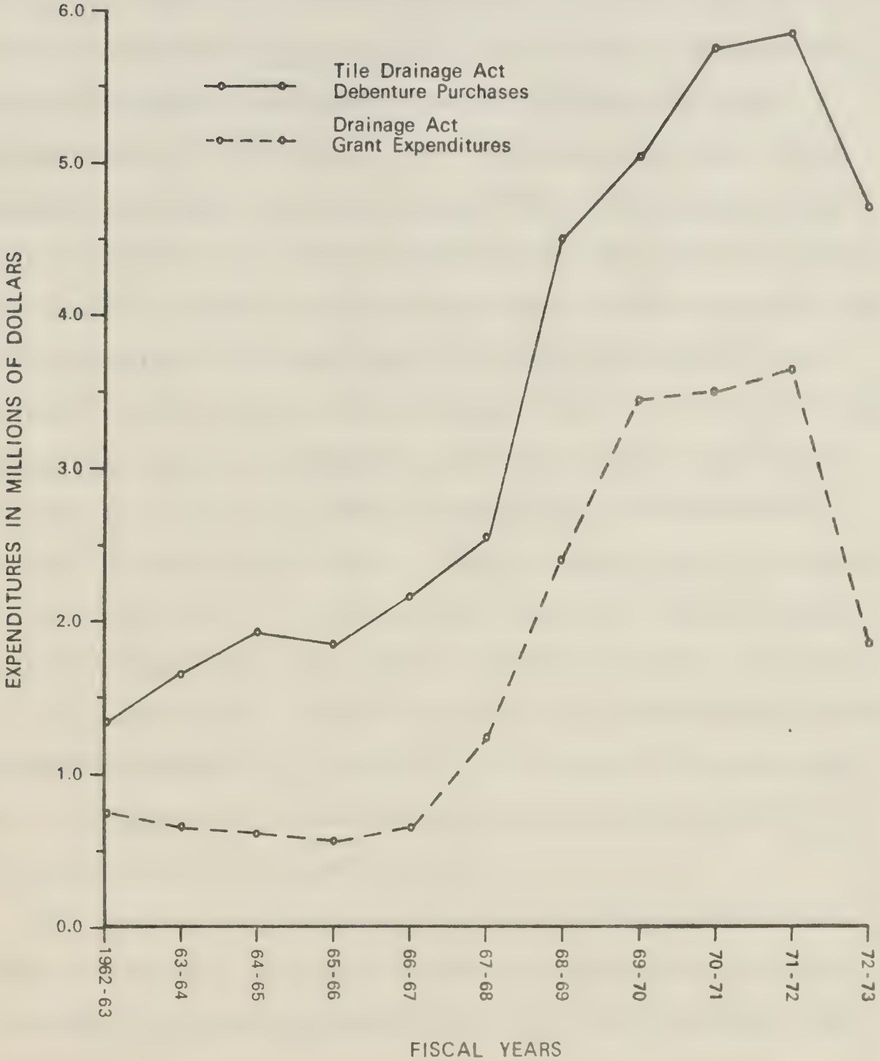
In this section the amounts and regional distribution of provincial government expenditures in the form of grants under The Drainage Act are discussed. It is pointed out in the preceding section that grants amounting to 33 1/3 percent of the total costs are paid on municipal drainage works on agricultural land constructed within counties, 66 2/3 percent of the total cost on works constructed in territorial districts or provisional counties, and up to 80 percent of the total costs of

works constructed in unorganized territories. The grants under The Drainage Act are examined both in terms of the provincial total annual expenditures for the period 1962-72 and on the basis of the township by township variations for the period 1964-71.

(a) Annual Drainage Act Expenditures, 1962-72. The graph, Figure 2.1, details the total grants paid under The Drainage Act for each year during the period 1962-72. During the first four years of the period the expenditures decreased slightly from a total of $751,194 in 1962-63 to $567,405 in 1965-66. In 1966, the annual expenditures began to increase rapidly through the four-year period to 1969-70 in which the total amounted to $3,493,000. This expenditure level of 1969-70 was maintained through the next two years before the total dropped off to $1,882,185 in 1972-73. The variations observed in the magnitudes of annual expenditures of grants under The Drainage Act can be related to the other municipal drainage assistance programmes which were in effect for portions of the eleven-year period.

The two most significant programmes of additional assistance for municipal drainage were the A.R.D.A. Drainage Outlet Assistance Programme and the Ontario Department of Agriculture and Food's Special Agricultural Drainage Assistance Programme. The A.R.D.A. programme provided for a drainage assistance grant of 33 1/3 percent to be paid on all drainage works located in the counties of the southern part of the province and which were petitioned after April, 1966 and constructed prior to the termination of the programme on December 31, 1968. Since December, 1968 the A.R.D.A. assistance has been available only in Eastern Ontario. When the A.R.D.A. assistance programme was terminated, the Ontario Department

Figure 2.1 Province of Ontario Grant Expenditures Under the Drainage Act and Debenture Purchases Under the Tile Drainage Act 1962-1972



Source: Ontario Public Accounts 1962-1972

of Agriculture and Food initiated the Special Drainage Assistance Programme which provided grants of 33 1/3 percent for projects petitioned under the A.R.D.A. programme but which were constructed too late to qualify for the A.R.D.A. grants.

The relatively stable level of expenditures under The Drainage Act for the years 1962-63 to 1965-66 corresponds to a period when only the assistance provided by The Drainage Act was available. The period of 1966-67 to 1969-70 in which grant expenditures increased sharply corresponds to the period during which the A.R.D.A. programme and the provincial government's Special Drainage Assistance Programme provided additional grants. The period of levelling off from 1969-70 to 1971-72 corresponds to a period when projects petitioned prior to December, 1968 were still eligible for grants under the Special Drainage Assistance Programme but when newly petitioned projects were only eligible for The Drainage Act grants. The final year, 1972-73, in which expenditures fell off, is a year in which most of the projects constructed would have been eligible only for grants under The Drainage Act. In summary, the graph, Figure 2.1, illustrates quite clearly the effect of additional assistance programmes on the amount of drainage undertaken. While there is a time lag effect the initiation of the A.R.D.A. and Special Assistance Programmes corresponds to a period of rapid increases in expenditures; and the termination of these programmes corresponds to a period of levelling-off and then reduced expenditures.

(b) Drainage Act Expenditures By Township 1964-71. In order to obtain an overview of the regional patterns of drainage expenditures, an analysis of the annual expenditures at the township level was under-

taken. The period of 1964-71 was selected for analysis in order to include the 1964-66 period during which expenditures were relatively stable, the 1966-69 period of rapid increase, and the 1969-72 period of renewed stability. It was hoped that an analysis of grant expenditures at the township level over the eight-year period would reveal the regional trends in drainage activity.

The basic data employed in this analysis were the annual total of grants under The Drainage Act paid to each township in the province. The initial stage of analysis involved the mapping of these expenditures for each of the eight years. The resulting maps provided an overview of expenditure patterns but were limited in their usefulness by extreme year-to-year variations in expenditures, particularly in areas of limited drainage activity. In order to better summarize the pattern, average annual grant expenditures by townships in the southern part of the province were calculated and mapped for the three year periods 1964-65 to 1966-67, and 1969-70 to 1971-72. The former period corresponds to the timespan prior to the rapid increases of 1967-69 while the latter period corresponds to the years of renewed stability after the increases (Figure 3.1). The maps of these three-year average expenditures have been reproduced as Figures 2.3 and 2.4 and form the basis for the discussion of the patterns of drainage activity. Data for expenditures in the northern part of the province have not been mapped but are summarized in Table 2.1. Figure 2.2 is a reference map of county locations.

The map, Figure 2.3, illustrates the pattern of average annual drainage grants for the three-year period of 1964-65 to 1966-67 for townships in the southern part of the province. The pattern of drainage

Figure 2.2

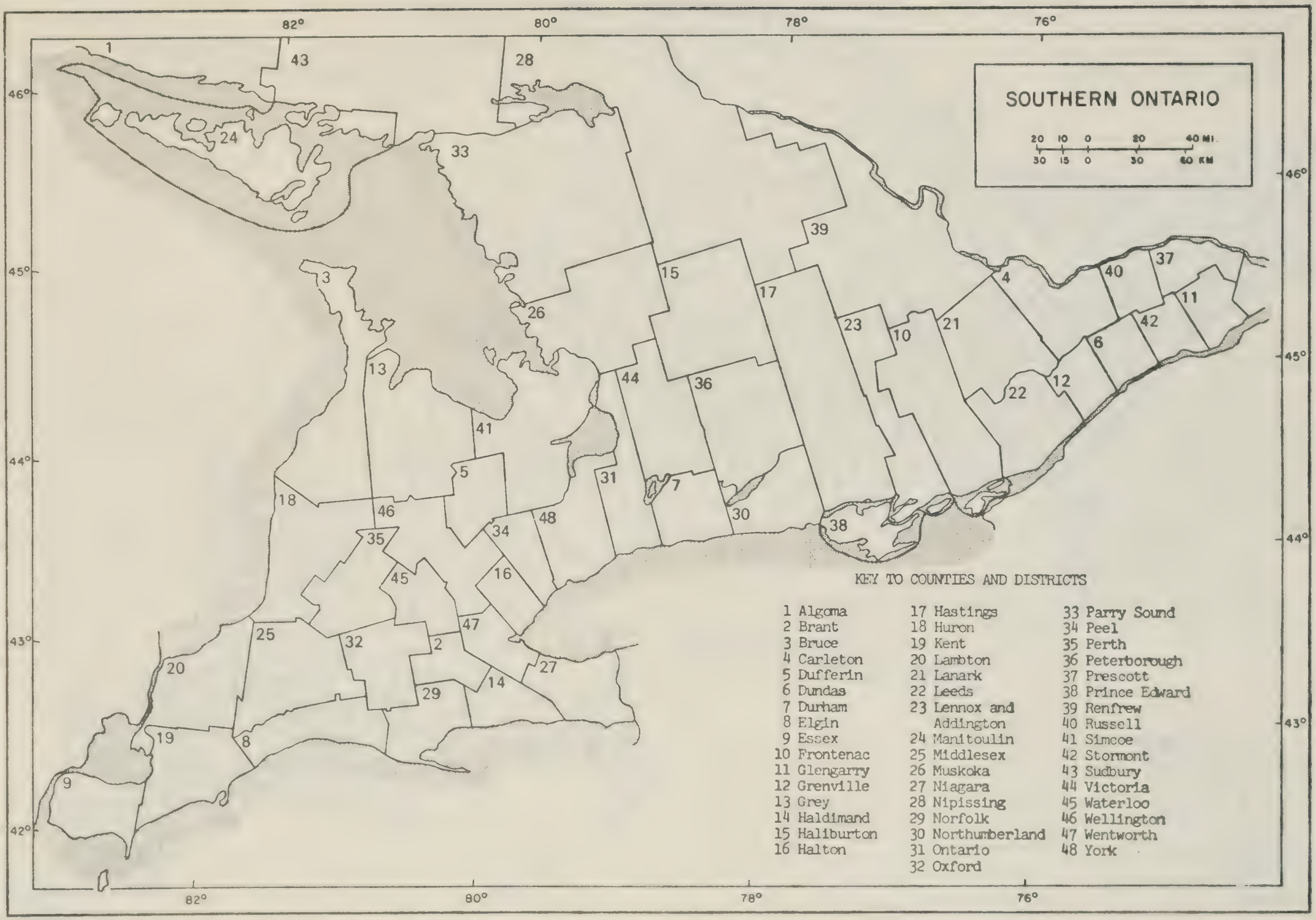

SOUTHERN ONTARIO
20 10 0 20 40 MI.
30 15 0 30 60 KM
KEY TO COUNTIES AND DISTRICTS
1 Algoma
2 Brant
3 Bruce
4 Carleton
5 Dufferin
6 Dundas
7 Durham
8 Elgin
9 Essex
10 Frontenac
11 Glengarry
12 Grenville
13 Grey
14 Haldimand
15 Haliburton
16 Halton
17 Hastings
18 Huron
19 Kent
20 Lambton
21 Lanark
22 Leeds
23 Lennox and Addington
24 Manitoulin
25 Middlesex
26 Muskoka
27 Niagara
28 Nipissing
29 Norfolk
30 Northumberland
31 Ontario
32 Oxford
33 Parry Sound
34 Peel
35 Perth
36 Peterborough
37 Prescott
38 Prince Edward
39 Renfrew
40 Russell
41 Simcoe
42 Stormont
43 Sudbury
44 Victoria
45 Waterloo
46 Wellington
47 Wentworth
48 York

Figure 2.3 Average Annual Value of Municipal Drainage Grants to Townships in Southern Ontario for the Period April 1, 1964 to March 31, 1967

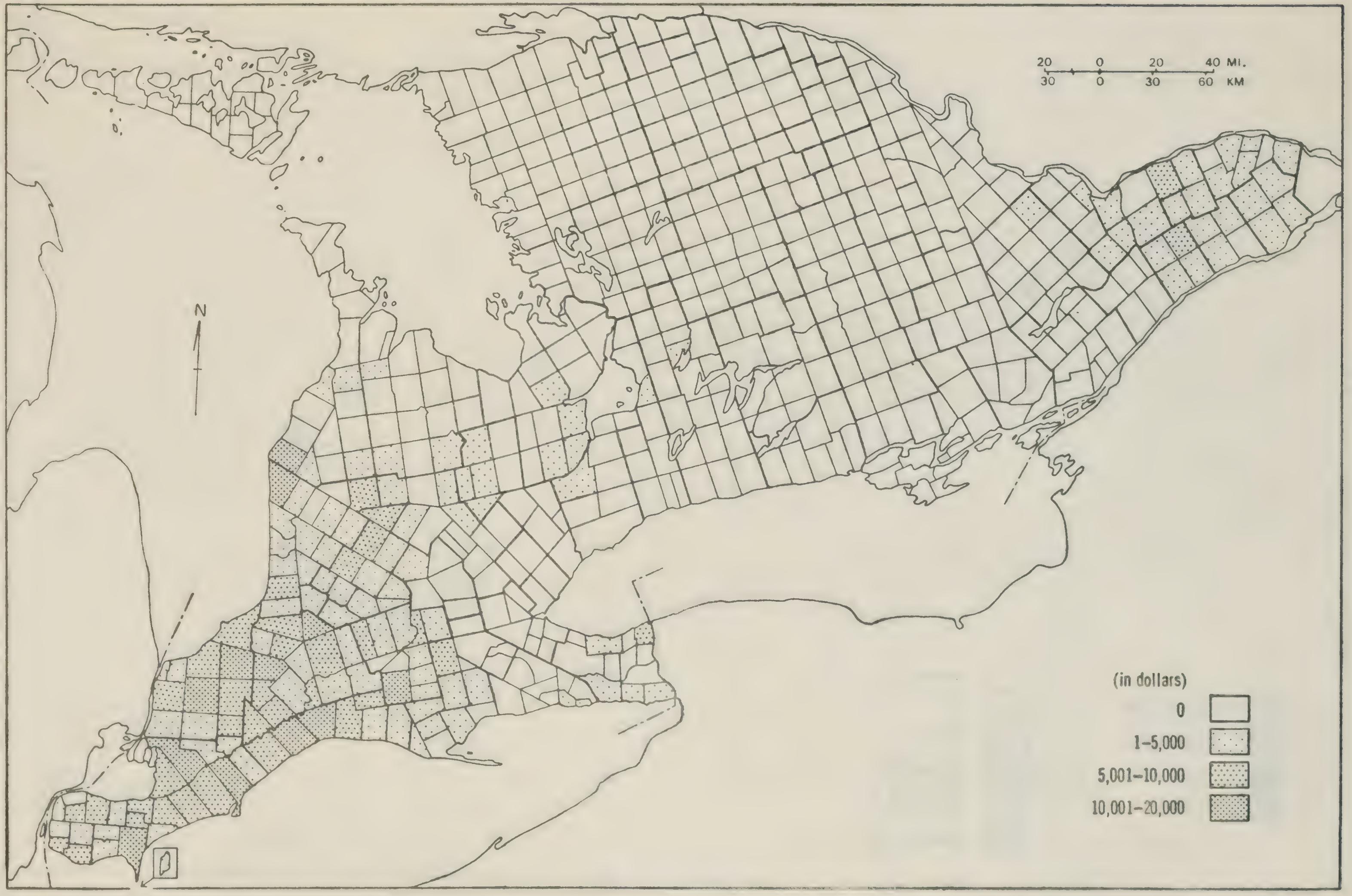


Figure 2.4 Average Annual Value of Municipal Drainage Grants to Townships in Southern Ontario for the Period April 1, 1969 to March 31, 1972

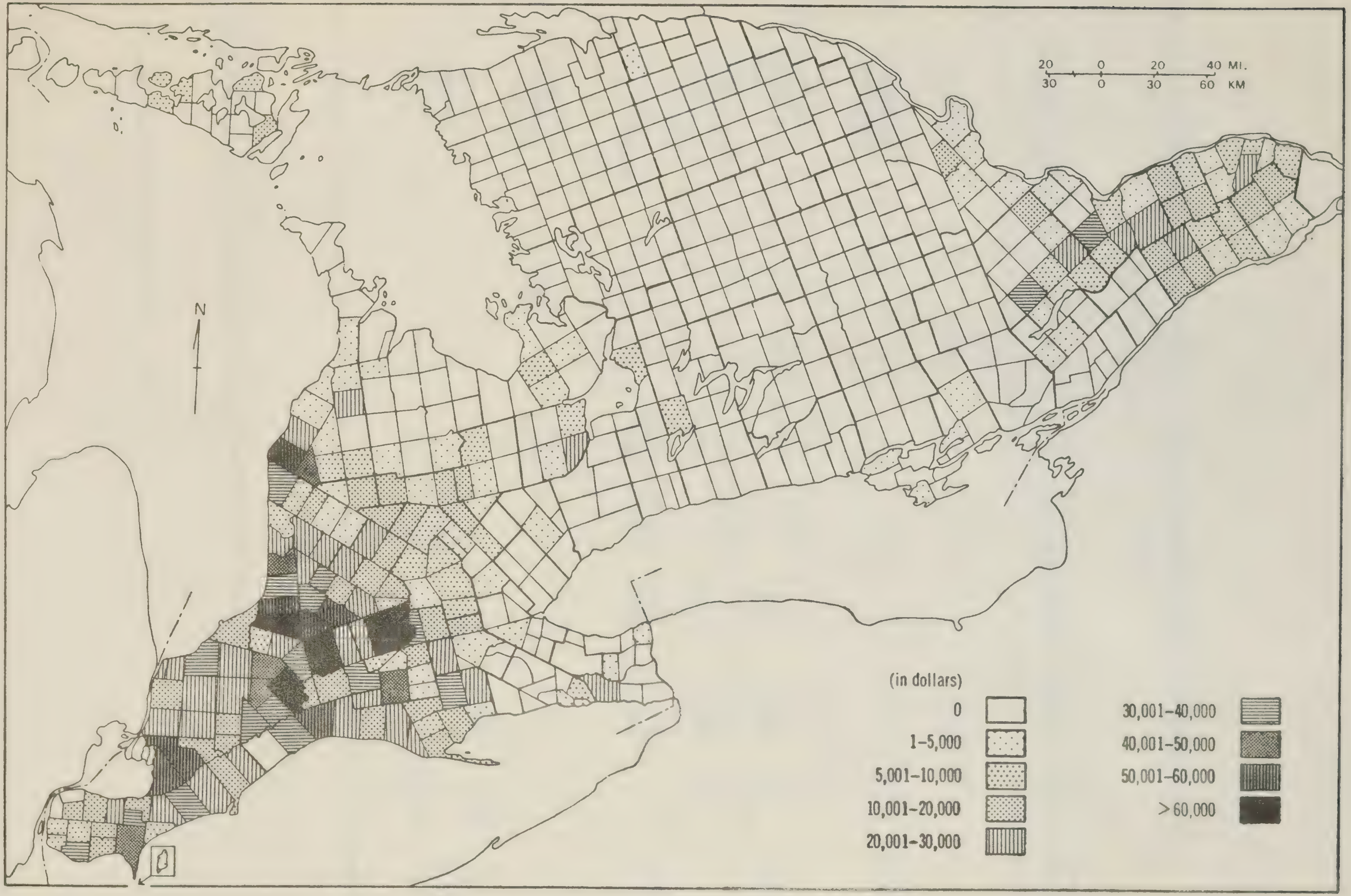


TABLE 2.1

PROVINCE OF ONTARIO MUNICIPAL DRAINAGE GRANTS UNDER THE DRAINAGE ACT TO MUNICIPALITIES

IN NORTHERN ONTARIO 1964 - 1972*

DISTRICT	MUNICIPALITY**	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	1971-72
Algoma	Thessalon	-	837	-	-	-	-	-	-
Nipissing	Caldwell	-	-	-	-	-	7,337	20,174	64,825
	Springer	-	-	-	-	-	-	2,393	25,279
Rainy River	Alberton	-	-	-	635	-	-	-	-
	Atwood	-	6,999	13,235	7,332	-	-	-	-
	Blue	-	-	-	-	786	5,742	-	1,445
	Emo	-	-	-	2,032	-	-	1,146	-
	LaVallee	-	-	-	2,139	-	3,132	-	-
	McCrosson Tovell	-	-	1,779	-	1,433	1,537	-	-
	Morley	-	-	1,440	8,366	3,587	9,263	963	2,449
	Worthington	-	-	2,948	2,105	829	1,006	-	-
Sudbury	Casimir Jennings Appleby	26,509	-	2,557	-	-	-	-	-
Timiskaming	Armstrong	-	-	-	-	-	24,815	962	-
	Dymond	-	-	-	-	792	-	-	-
	Harley	-	-	-	-	-	-	-	8,093
	Kerns	-	-	-	-	-	-	10,520	-

* All values are in dollars.
** Only municipalities with Municipal Drainage Grants have been listed.

Source - Ontario Public Accounts 1964 - 1972

activity during this time can be described as indicating two major regions of activity, one in Southwestern Ontario and the other in Eastern Ontario, with a few smaller areas in the counties of Bruce, Grey, Dufferin, Wellington and Simcoe. In interpreting the map it is important to recognize that the expenditures detailed on the map are all for municipalities located within counties and, therefore, represent grants of 33 1/3 percent of the total costs of the projects. In the Southwestern Ontario region of drainage activity, twelve townships received between $10,000 and $20,000 in average annual grants under The Drainage Act. Within the Eastern Ontario region only two townships received average annual grants over $5,000. The map also reveals a large region with no municipal drainage activity including the area around the western end of Lake Ontario and the area east and north from Toronto.

The grant expenditures under The Drainage Act for municipalities in the northern part of the province are summarized for the entire 1964-71 period in Table 2.1. In this part of the province the municipalities receiving grants are located either in provisional counties or territorial districts and therefore receive grants of 66 2/3 percent of the cost of drainage. The data in the Table indicate that during the 1964-66 period only six municipalities received grants, and of these only two received an average annual grant of over $5,000.

The second map of grant expenditures under The Drainage Act, Figure 2.4, details the average annual grants for the three-year period 1969-70 to 1971-72 by townships for the southern part of the province. The pattern of drainage activity is similar to that of the 1963-67 period with two major areas of activity, one in Southwestern Ontario and another in Eastern

Ontario, and more isolated activity in the counties of Simcoe, Ontario, Victoria, and Prince Edward. Both the area of activity in the southwest and that in the east are larger than for the previous period with the former area being extended north and eastwards and the latter area being extended north and west. The most significant change from the earlier period relates to the magnitudes of the expenditures. In the area of drainage activity in Southwestern Ontario, five townships received average annual grants of over $60,000 and 29 other townships received average annual grants in excess of $30,000. In Eastern Ontario five townships received average annual grants of over $20,000. Again a significant lack of municipal drainage activity is observed in the area around the western end of Lake Ontario and in the area to the east and north of Toronto, although there was some activity in isolated townships in the counties of Ontario, Victoria and Prince Edward.

The data in Table 2.1 on grant expenditures in the northern part of the province indicate only limited activity in the north during the 1969-72 period. Only eleven townships received grants during the period, and of those townships only one received an annual average grant of over $30,000 and one other above $5,000. Grants in this area represent 66 2/3 percent of the total cost of the projects.

In order to better illustrate the changes in the amount and regional patterns of grant expenditures under The Drainage Act during the 1964-71 period in the southern part of the province, two further maps were prepared. The first map, Figure 2.5, shows the percentage change in the average annual value of Drainage Act grants to townships between the period 1964-67 and 1969-71. The second map, Figure 2.6, shows the actual

Figure 2.5 Percentage Change in the Average Annual Value of Municipal Drainage Grants to Townships in Southern Ontario Between the Periods April 1, 1964 to March 31, 1967 and April 1, 1969 to March 31, 1972

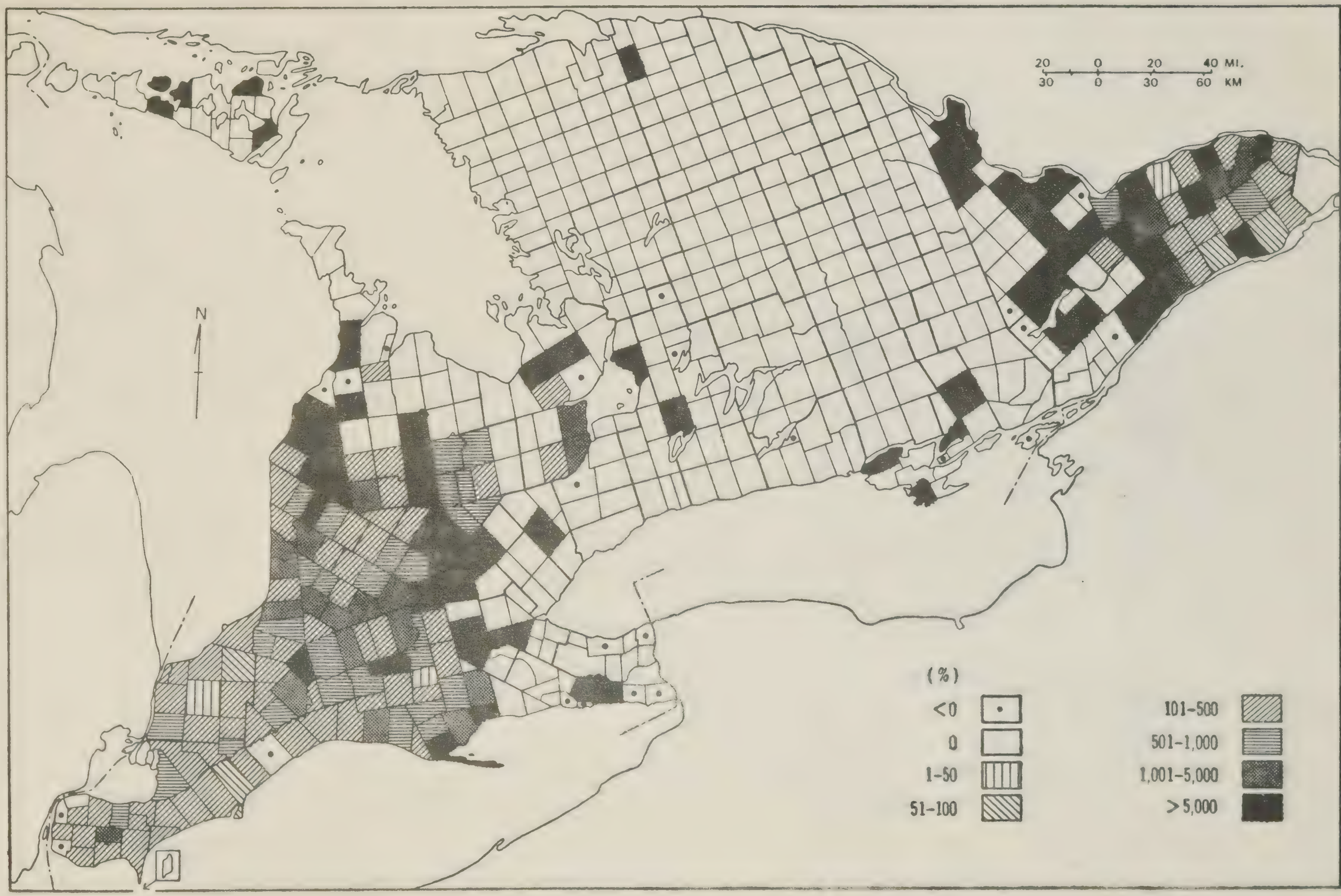
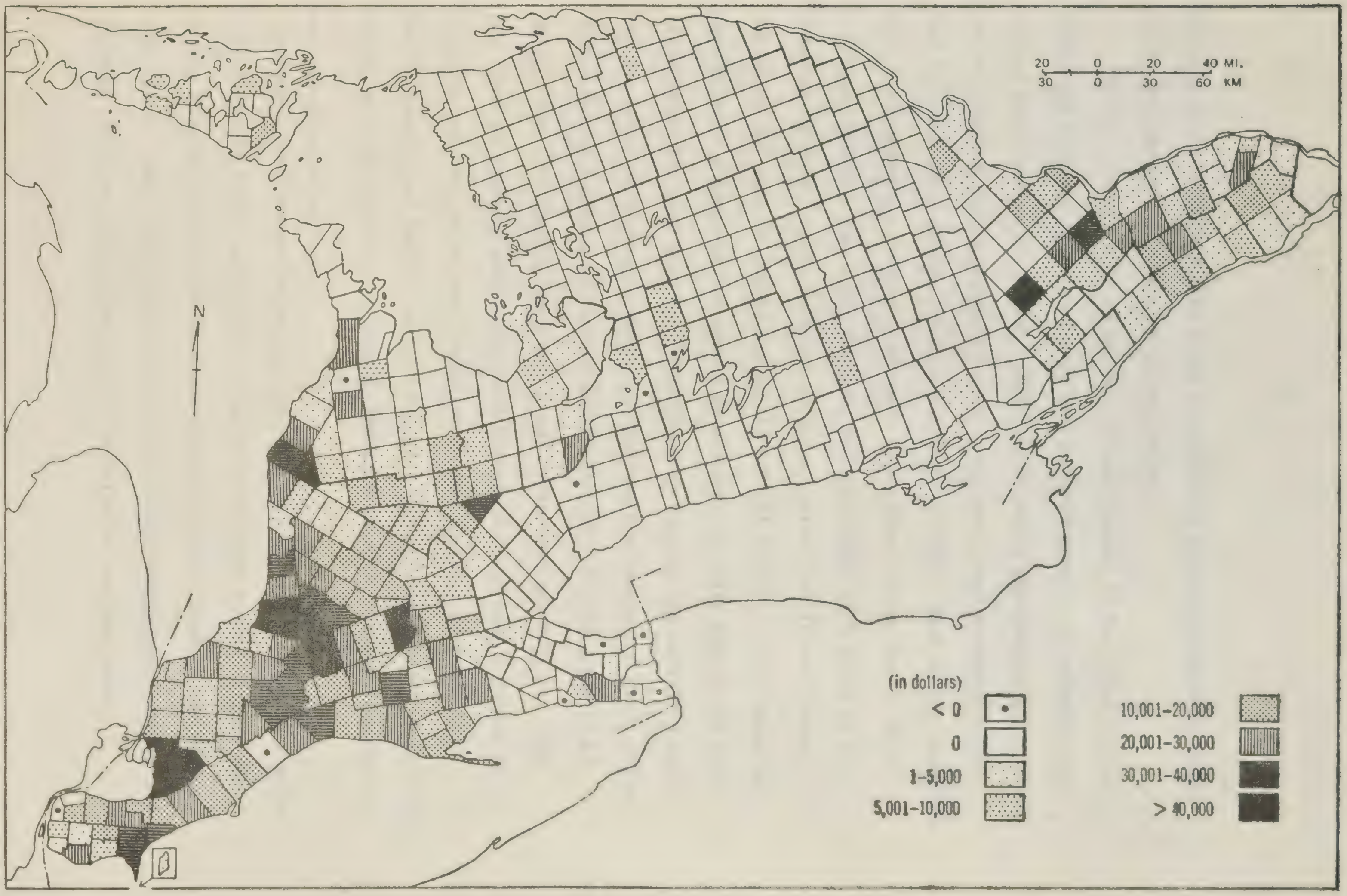


Figure 2.6 Actual Increase in the Average Annual Value of Municipal Drainage Grants to Townships in Southern Ontario Between the Periods April 1, 1964 to March 31, 1967 and April 1, 1969 to March 31, 1972



increase inthe average annual value of municipal drainage grants to townships between the periods 1964-67 and 1969-71.

The map, Figure 2.5, of the percentage changes in the value of grants under The Drainage Act illustrates the relative changes in expenditures. Only a small number of isolated townships actually experienced a decrease in the level of expenditures and in no case were these townships which had received large grants during the 1964-67 period. Most of the townships with the highest percentage increases, those shown on the map to have increases greater than 5,000 percent, are associated with areas of new drainage activity* which received no grants during the 1964-67 period but which did receive grants during the 1967-71 period. These areas of new activity illustrate the spread of drainage activity out of the two established drainage regions of Southwestern Ontario and Eastern Ontario. The new areas of drainage associated with the Southwestern Ontario region form a crescent-shaped pattern including townships in the counties of Bruce, Grey, Wellington, Waterloo, Brant, Wentworth and Norfolk. The new areas of drainage associated with Eastern Ontario show a spread of activity west and north into townships in the counties of Grenville, Leeds, Lanark, and Renfrew and the Regional Municipality of Ottawa-Carleton. Other areas of new activity include isolated townships in the counties of

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*The term "new" as applied to drainage activity in this chapter is a relative term indicating activity in areas which did not receive grants early in the 1964-71 period but which have received grants later in the period. This use of "new" should not be confused with the distinction between new drainage works and the reconstruction of existing drainage works.

Haldimand, Peel, Simcoe, Ontario, Victoria, Hastings, Prince Edward and Lennox and Addington in the Lake Ontario area and in the areas of Nipissing South and Manitoulin Island farther north. In interpreting the map of the percentage increases in grants, it is important not to overlook the large number of townships located within the established drainage areas of Southwestern and Eastern Ontario which experienced large percentage increases in the range of 500 to 5,000 percent. In terms of the absolute increases in expenditures under The Drainage Act, it is in these areas where the greatest activity has taken place.

The fourth map in the series related to the expenditures of grants under The Drainage Act, Figure 2.6, presents data on the actual increase in the average annual grant expenditures between the periods 1964-67 and 1969-72. This map clearly shows where the maximum increases in the absolute value of grants have occurred. These maximum increases are largely concentrated in the southwestern drainage area, particularly in Lambton and Middlesex counties with lesser concentrations in Essex, Elgin, Huron, Bruce and Perth counties. With only local exceptions, the magnitudes of absolute increases in the value of grants in Eastern Ontario are much smaller than those in the southwest. The absolute increases in other areas of the province are relatively insignificant when compared to those in the two major areas.

The four maps relating to grant expenditures under The Drainage Act illustrate the concentration of drainage activity in the regions of Southwestern and Eastern Ontario. The areas of new drainage seem to correspond to the fringes of these established areas. In terms of the absolute values of expenditures the predominant position of Southwestern Ontario has been well established.

2.4 Debenture Purchases Under the Tile Drainage Act 1964-72

In this section the amounts and regional distribution of provincial government expenditures in the form of debenture purchases under The Tile Drainage Act are considered. As discussed in Section 2.2 of this report The Tile Drainage Act provides for assistance in the form of low-interest debenture purchases by the province from municipalities in order to enable municipalities to make low-interest loans to landowners completing tile drainage projects. The loans can cover up to 75 percent of the total cost of tile drainage. While the values of such loans do not always represent 75 percent of the total cost of the tile drainage projects, it is assumed that the available data provide a relative indication of the amounts and patterns of expenditures on tile drainage. While the primary purpose of this report is to study municipal drainage projects, this section on tile drainage has been included as a basis for consideration of the relationships between the patterns of expenditures on the two types of drainage.

(a) Annual Tile Drainage Expenditures 1962-72. The annual totals for provincial government purchases of debentures under The Tile Drainage Act for the period 1962-72 have been plotted on the graph, Figure 2.1. The pattern of expenditures indicates a gradual increase of expenditures during the period 1962-67, a period of more rapid increase in expenditures from 1967-70, a levelling off to 1971, and a falling off in 1972. This pattern of expenditures is quite similar to that described for expenditures on municipal drainage under The Drainage Act (See Figure 2.1 and Section 2.3a), with the expenditures under The Tile Drainage Act exhibiting a slight lag behind those under The Drainage Act. This lag is easily

explained in that on-farm tile drainage projects are likely to follow the installation of municipal outlet drains. The graph of tile drainage expenditures does not exhibit the extremely sharp breaks in slope which are associated with the municipal drainage expenditure graph. This difference can be attributed to the fact that the initiation and cancellation of the A.R.D.A. Outlet Drainage Assistance Programme did not have the direct impacts on tile drainage activity that it had on municipal drainage activity. On the basis of the graph, Figure 2.1, one may advance the hypothesis that in general terms the tile drainage expenditure pattern for 1962-72 is closely related to the municipal drainage expenditures, with the municipal drainage activity in most cases triggering subsequent tile drainage activity. This hypothesis is further examined in the following sections which involve the discussion of the regional patterns of expenditure under The Tile Drainage Act.

(b) Tile Drainage Act Expenditures by Township 1964-71. In order to provide a basis for a comparison of the regional patterns of expenditures under The Tile Drainage Act and The Drainage Act an analysis of the annual township level expenditures under The Tile Drainage Act was undertaken. This analysis was quite similar to that described in Section 2.3b for The Drainage Act expenditures. The period 1964-71 was selected to correspond to that considered for The Drainage Act and to include the 1967-69 period of rapid increases in tile drainage activity. The basic data employed were the annual totals for provincial government purchases of debentures under The Tile Drainage Act from each township in the province. The initial stage in this analysis involved the preparation of maps of the tile drainage expenditures for each of the eight years.

In order to provide a basis for a comparison with the maps for The Drainage Act expenditures and to overcome the extreme year-to-year variations of expenditures in some areas, a series of four summary maps were prepared. These four maps which are directly comparable to those included in this report for The Drainage Act expenditures, are maps of the average annual expenditures on tile drainage debentures for the three-year periods 1964-66 and 1966-71, Figures 2.7 and 2.8 respectively, and maps of percentage differences and actual increases in tile drainage debentures purchases between the two periods, Figures 2.9 and 2.10, respectively.

Figure 2.7 is a map of the average annual value of tile drainage debenture purchases by township in the southern part of the province during the period of 1964-65 to 1966-67. The map reveals a pattern of major activity in Southwestern Ontario and lesser amounts of activity in the counties bordering the shores of Lake Huron and southern Georgian Bay, in the Niagara Peninsula, in a band along the north shore of Lake Ontario, and in Eastern Ontario. The largest expenditures are concentrated in Southwestern Ontario, particularly in the counties of Essex, Kent, Lambton and, to a lesser extent, in Middlesex, Huron, Perth and Elgin.

Figure 2.8 is a map of the average annual value of tile drainage debenture purchases by township in the southern part of the province for the period 1969-70 to 1971-72. The regional pattern of expenditures is quite similar to that for the earlier period as illustrated in Figure 2.7. The magnitudes of expenditures are notably larger than during the earlier period. The major center of activity is still the southwest, particularly the counties of Huron, Perth, Lambton, Middlesex, Essex, Kent and Elgin. There is a considerable increase in activity in Eastern

Figure 2.7 Average Annual Value of Tile Drainage Debenture Purchases by Townships in Southern Ontario for the Period April 1, 1964 to March 31, 1967

Figure 2.8 Average Annual Value of Tile Drainage Debenture Purchases by Townships in Southern Ontario For the Period April 1, 1969 to March 31, 1972

Figure 2.9 Percentage Change in the Average Annual Value of Tile Drainage Debenture Purchases by Townships in Southern Ontario Between the Periods April 1, 1964 to March 31, 1967 and April 1, 1969 to March 31, 1972

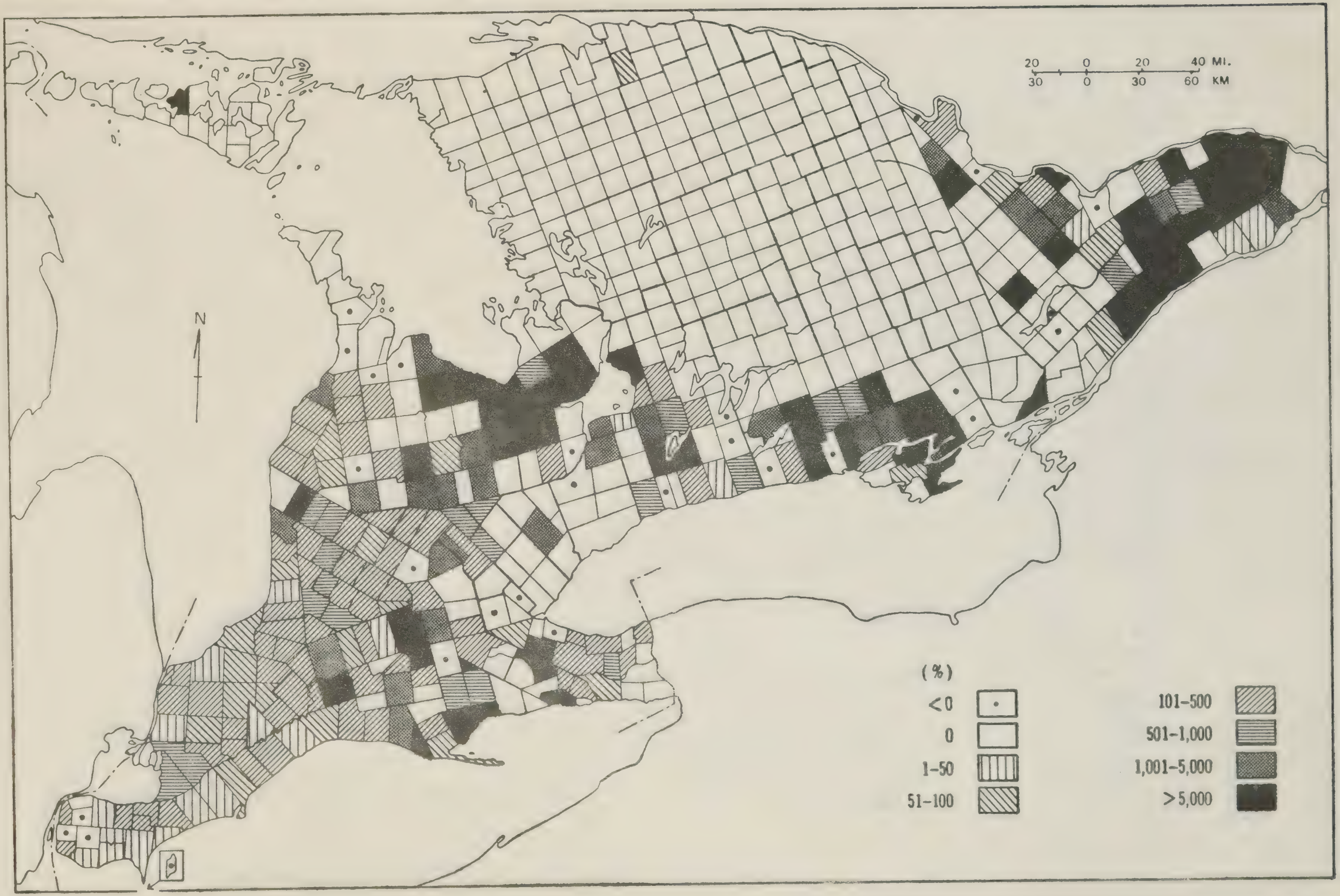
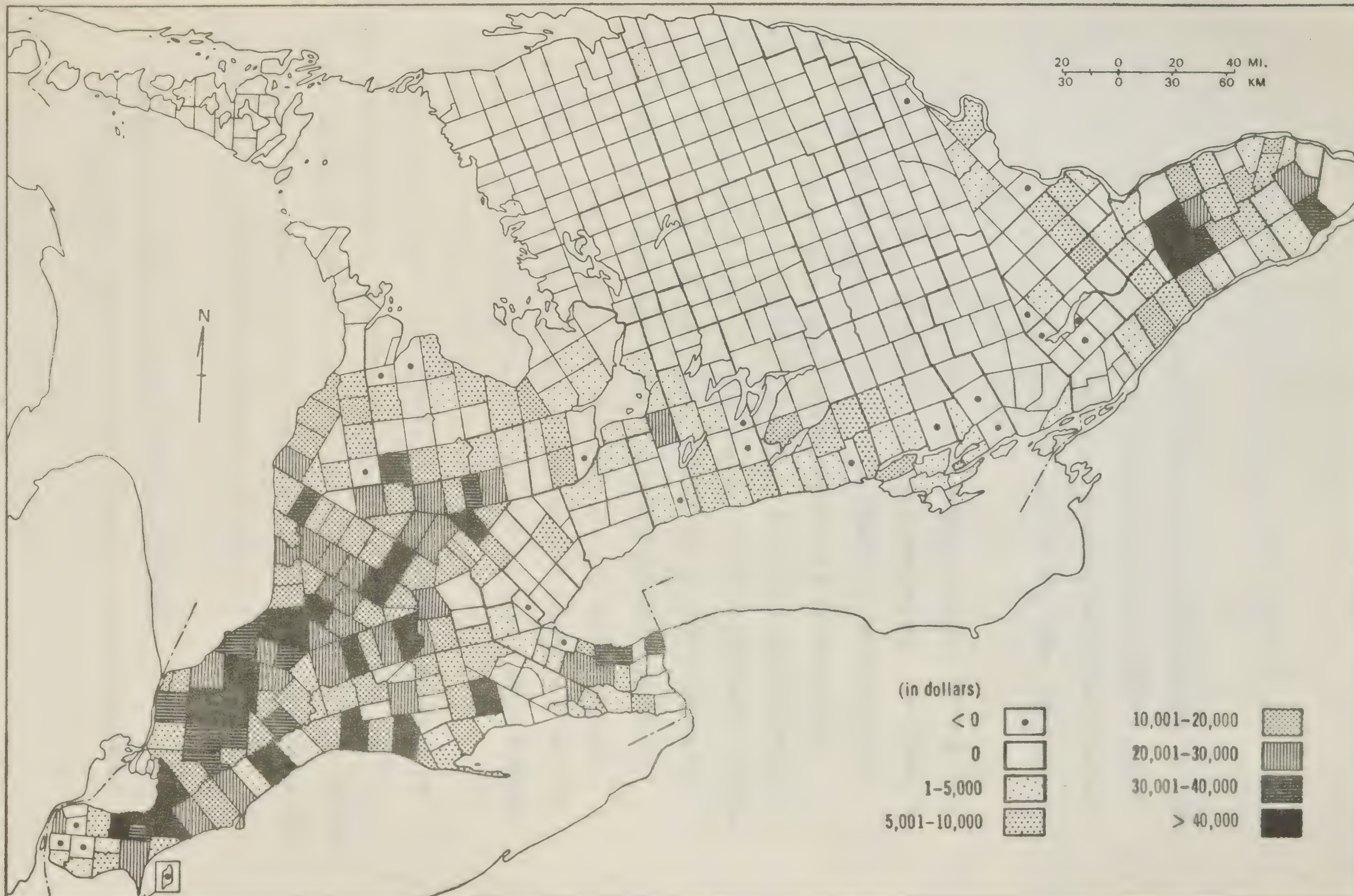


Figure 2.10 Actual Increase in the Average Annual Value of Tile Drainage Debenture Purchases by Townships in Southern Ontario Between the Periods April 1, 1964 to March 31, 1967 and April 1, 1969 to March 31, 1972



Ontario as well as lesser increases along the north shore of Lake Ontario and in Simcoe county.

The Tile Drainage debenture purchases for the municipalities in the northern part of the province for the entire 1964-65 and 1971-72 period are summarized in Table 2.2. Throughout the period only fifteen municipalities took advantage of the programme, and in most cases the average annual expenditures were quite small.

The final two maps presented in this section, Figures 2.9 and 2.10, illustrate the regional patterns of percentage and actual increases in the average annual values of tile drainage debenture purchases. The highest percentage increases are again associated with areas of new tile drainage activity. These areas of new activity as identified in Figure 2.9 include townships in the counties of Huron, Middlesex, Oxford, Norfolk and Haldimand in the western part of Southern Ontario; in the counties of Grey and Simcoe, south of Georgian Bay; along the north shore of Lake Ontario; and in Eastern Ontario. The greatest actual increases in tile drainage activity as revealed in Figure 2.10 are concentrated in the southwestern part of the province with a small secondary concentration in Eastern Ontario.

The series of four maps relating to tile drainage have served to emphasize the absolute importance of the Southwestern Ontario region. Lesser amounts of tile drainage activity and new areas of activity included the Niagara Peninsula, the area south of Georgian Bay, the area along the north shore of Lake Ontario, and Eastern Ontario.

2.5 Regional Overview of Drainage Activity 1964-1972

In the preceding sections of this chapter the various government

TABLE 2.2

PROVINCE OF ONTARIO TILE DRAINAGE DEBENTURE PURCHASES FROM MUNICIPALITIES IN NORTHERN ONTARIO 1964 - 1972*

DISTRICT	MUNICIPALITY**	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	1971-72
Nipissing	Caldwell	-	-	3,200	1,500	-	-	-	-
	Chisholm	-	-	1,000	7,100	-	-	3,400	-
	Springer	-	-	-	4,000	-	-	-	-
Timiskaming	Armstrong	-	-	-	8,200	6,700	16,900	11,300	16,400
	Casey	-	-		3,000				
	Dack	-	-	6,200	-	2,100	-	-	-
	Dymond	-	500	-	-	-	4,000	18,900	5,000
	Evantural	-	-	7,400	-	6,300	11,800	3,800	8,400
	Harley	-	-	-	-	6,400	-	13,600	6,000
	Harris	-	-	-	-	-	-	-	1,100
	Hilliard	-	-	-	-	-	7,500	4,500	4,500
	Hudson	-	-	-	-	-	21,500	-	-
	Kerns	-	-	-	-	17,200	5,000	32,200	16,100
	Chamberlain	-	-	-	-	-	-	-	4,500
Rainy River	Worthington	-	-	-	-	-	9,000	-	-

* All values are in dollars.

** Only municipalities from which Tile Drainage Debentures were purchased have been listed.

Source: Ontario Ministry of Agriculture and Food, Food Production and Rural Development Division, Agricultural and Horticultural Societies Branch, October 1972.

drainage assistance programmes have been reviewed, and the magnitudes and regional patterns of government expenditures related to The Drainage Act and The Tile Drainage Act have been examined. In the final section of this chapter an attempt is made to present an integrated summary of the patterns previously discussed and to offer possible explanations for the relationships involved. The summary of expenditure patterns is presented on a regional basis; and an attempt is made to relate these patterns to recent trends in agricultural activity.

During the early stages of this project, the researchers undertook an in-depth multivariate statistical analysis of the relationships of government drainage assistance expenditures to township-level agricultural statistics as derived from the 1971 census. These analyses resulted in an unpublished background report (Freeman, 1973) which has served as a useful reference in the completion of this final report. The background report and the relevant data sets are on file with the researchers.

Over the past two decades considerable changes have occurred in the agricultural production of field crops in Ontario. These changes include increases in the yields of most crops and shifts in the magnitudes and regional distributions of acreages in various crops. For the most part these changes have been related to the development of new crop varieties suited to local conditions and the use of more intensive soil and crop practices. A survey of the changes in crop yields and acreages by counties for the period 1948-1968 has been published recently (Dilamarter and McDonald, 1971), while McDonald (1972) has provided a detailed county-level analysis of crop patterns for 1968.

In many areas land drainage activity has no doubt been an important

factor in the changing patterns of agricultural production. While it is beyond the scope of this report to provide a detailed provincial-scale analysis of the relationships of drainage activity to the changing patterns of agricultural production, an attempt is made to generalize on a regional basis the dominant trends.

On the basis of the patterns of government expenditures on drainage under The Drainage Act, as revealed in Figures 2.3 to 2.6, and the patterns of expenditures under The Tile Drainage Act, as revealed in Figures 2.7 to 2.10, it is possible to identify several loosely defined regions of drainage activity. As a basis for the discussion which follows seven zones or regions of drainage activity have been identified. These zones are as follows: Southwestern Ontario, Southwestern Ontario Fringe, Southern Georgian Bay, Eastern Ontario, Niagara, North Shore Lake Ontario, and Northern Ontario.

The Southwestern Ontario Region of drainage activity may be characterized as including the counties of Essex, Kent, Lambton and the western parts of Middlesex and Elgin. This area has traditionally dominated Ontario agricultural production. It is in this area that the most significant increases in crop yields have taken place, and it is this area that dominates in the acreages in field crops, particularly shelled corn and soybeans (Dilamarter and McDonald, 1971 and McDonald, 1972). As revealed in the maps of drainage assistance expenditures this area has been predominant in the patterns of drainage assistance expenditures for both municipal drainage and tile drainage. Over the period 1964-71 the region consistently received the largest amounts of government drainage assistance.

The second region of drainage activity identified is the Southwestern

Ontario Fringe area, which may be characterized as including a broad band of counties north and east of the Southwestern Ontario area and west of a line joining the southern part of Bruce County to Haldimand County. In both agricultural production and drainage activity this zone is second only to the southwestern region. The field-crop production patterns are marked by recent substantial increases in shelled corn production, particularly in the southern counties of Elgin, Middlesex, Norfolk, Oxford, Brant and Haldimand. Fodder corn is grown generally throughout the area with wheat gaining importance particularly in Norfolk, and mixed grains being well established in the northern part of the zone in the counties of Perth, Huron, and Waterloo. The maps of drainage expenditures indicate that while drainage activity has been prevalent in this area throughout the 1964-71 period, recent years have seen major increases in expenditures.

The third region of drainage activity identified is that of Southern Georgian Bay, and includes the counties of Bruce, Grey, Wellington, Dufferin and Simcoe. During the 1964-72 period this area was the scene of a considerable amount of new drainage activity; the magnitudes of expenditures on drainage assistance increased significantly. During the same period agricultural production in this area showed a significant shift away from winter wheat and into fodder corn production. While drainage expenditures in this region are not nearly as large as in the two previously discussed regions the sustained activity requires recognition.

The fourth region of drainage activity is that of Eastern Ontario, the area east of a line through Renfrew and Frontenac Counties. In

this area there has been a dramatic increase both in municipal and tile drainage expenditures during the 1964-1972 period. In terms of crop production the area has experienced an increase in the production of fodder corn while oats and hay remain of some importance.

The fifth and sixth drainage regions identified are Niagara and the North Shore of Lake Ontario. These zones show the characteristic of being areas of considerable tile drainage activity but of only limited municipal drainage activity during the 1964-1971 period. It is suggested that this may be due to the topography of the areas which results in a denser network of natural water courses which may reduce the need for municipal drainage works.

The final zone of drainage activity is that of North Ontario. The activity in this zone has been limited to a few local pockets including Manitoulin Island, the Lake Nipissing Area, the Clay Belt areas of Timiskaming, and the Rainy River District.

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Chapter 3

THE GENERAL IMPACTS OF LAND DRAINAGE ON LAND USE AND THE ENVIRONMENT

3.1 Introduction

The draining of land has a number of direct and indirect impacts, which can be generalized in three categories: impacts on (1) agriculture, (2) the "natural" environment, and (3) non-agricultural land uses (Fig. 3.1). The impacts on agriculture are quite well known, and have been documented on numerous occasions. The impacts on the natural environment and on "other" land uses are much less clearly understood, and have sometimes been either completely overlooked or the subject of controversy. The purpose of this chapter is to trace briefly the kinds of links that appear to occur between land drainage and each of the three major categories. Two rather complex diagrams (Figs. 3.2 and 3.3) are used to characterize these links, diagrams whose development has proved to be very useful in the design of this research project. Two diagrams are used in recognition that drainage impacts are felt at a number of scales, ranging from the individual property through to provincial or larger scales. To simplify the discussion, impacts at the local and a loosely defined "large" scale will be considered. It will be noted that the important impacts of drainage tend to be different for the two scales.

3.2 Local-Scale Impacts

(a) agriculture

The farm-level effects of draining agricultural land have been recognized for centuries, and have played a vital role in the settlement

Figure 3.1

GENERALIZED MODEL OF THE IMPACTS OF LAND DRAINAGE

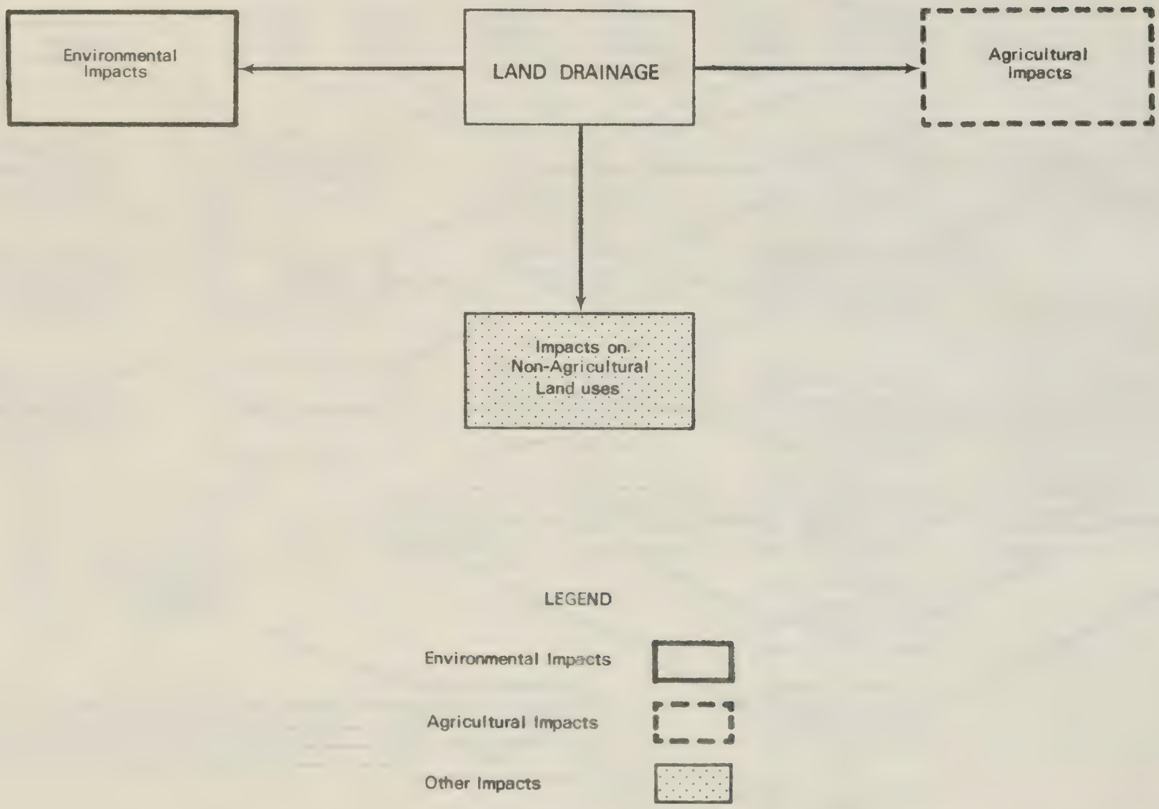
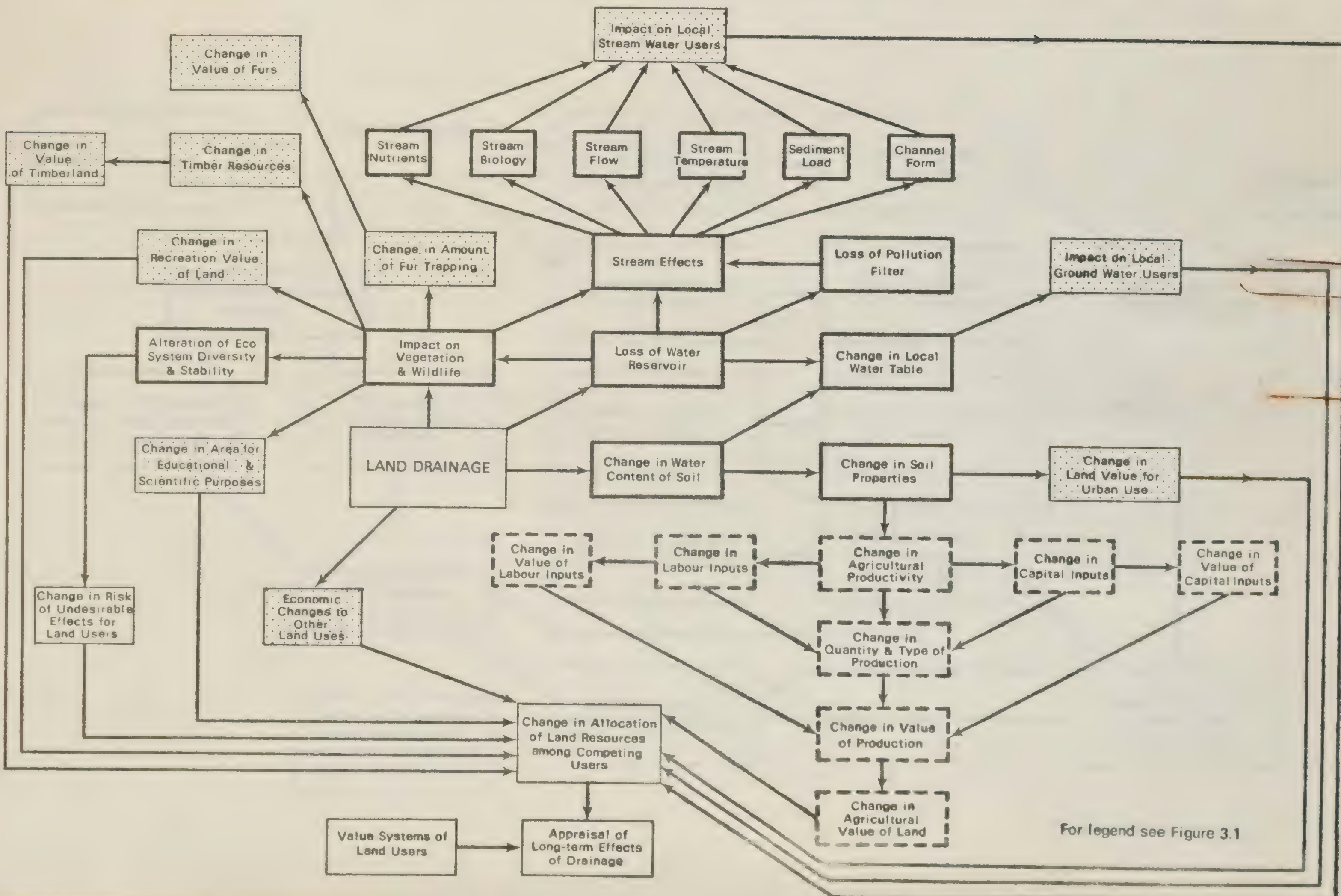


Figure 3.2

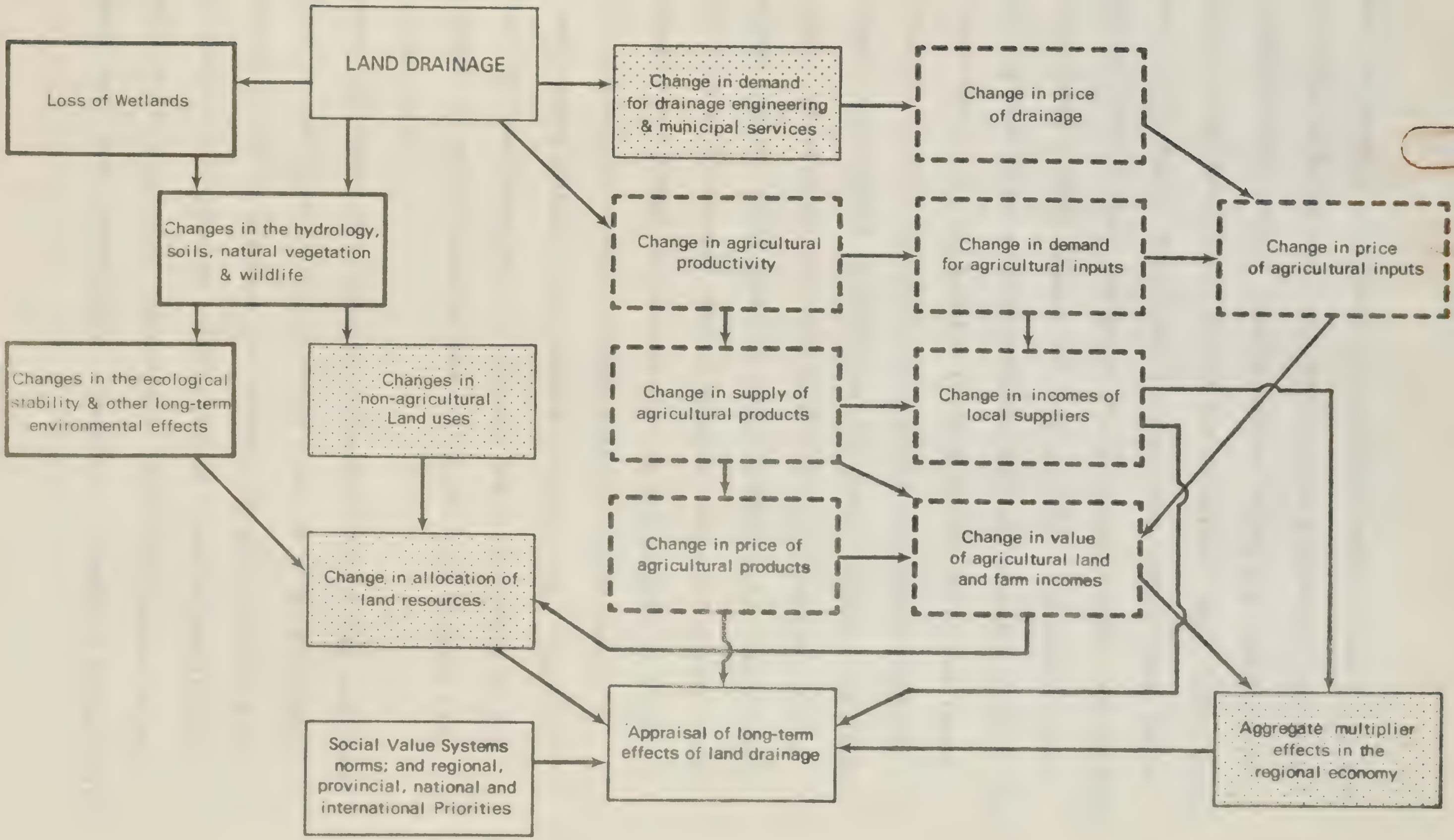
MODEL OF LOCAL IMPACTS OF LAND DRAINAGE



For legend see Figure 3.1

Figure 3.3

MODEL OF LARGE-SCALE IMPACTS OF LAND DRAINAGE



For legend see Figure 3.1

and economic development of Ontario. Theoretical analyses and field confirmation of these affects have been described in a number of papers and reports, some of which refer to farming within Canada and Ontario (see, e.g. Goldstein, 1971, Menz, 1964, Norton and MacMillan, 1970, Clark, 1970, Des Rivieres, 1971, Dillan, Perish and Pervis, 1961, Heard, 1969, Irwin, 1969, 1970, 1961, 1964, Irwin and Ayers, 1970, Roberts, 1950, TOPECON Group Limited, 1971, Kettel, 1973, Rigaux and Singh, 1973). The installation of drainage on a farm (i.e. a field underdrainage system which permits the removal of water from soil and carries it to an outlet which can remove the water from the site) will, if the soil is tillable and productive, change the basic agricultural potential of the farm. Normally the removal of water changes the properties of the soil so that it becomes aerated and may, perhaps for the first time, be easily cultivated. Less dramatic impacts occur when such drainage removes sporadic wet spots within fields that are normally cultivated, or permits tilling and seeding to occur earlier in the spring than usual. Another positive impact occurs if harvesting may procede without being impeded by wet ground. The net positive affect of these impacts is to improve the productivity of the soil or, at least, to permit existing production to occur without the impedments of wet land.

Improvement in productivity normally encourages one of two responses: (1) an increase in the yield of crops, or (2) a switch to more lucrative crops or rotations. Either response, of course, can have the affect of increasing incomes through sale of additional cash crops or additional livestock fed with the additional production. Since farm production is a complex system with many interrelated components, a change of productivity

should be associated with changes in other variables. Changes in the quantities and/or types of labour and capital could be expected to accompany radical shifts in production type or quantity (Found, 1971, Heady, 1952); and even changes in farm management practices might be required. For example, a common farm response to drainage installation in Ontario is a switch in crop production to corn. Corn growing, however, requires different amounts of labour throughout the year than many enterprises which may have preceded it; and new types of machinery and, sometimes, structures must be acquired. The final effect of a change in the farm system is a change in farm income (gross and net), which should, in time, be reflected in a change in land value. If the enhancement in income and value is large enough, the competitive value of land for agricultural purposes also changes. This may lead to the movement of formerly non-agricultural land into farm land, either through farm enlargement or the establishment of new farms. Conversely, drainage could cause the farmer with limited resources to switch from extensive types of production which consume a large acreage to the intensive and more lucrative cultivation of a reduced area.

Identifying the general categories of agricultural change is rather easy, since it can be deduced from standard farm-economic theory. But discovering the specific types and amounts of change is much more difficult, since it involves detailed field investigation. A thorough investigation would require several years of careful monitoring and record-keeping; but the researchers have attempted to make short-term estimates, primarily through the use of farm-level questionnaires.

(b) environmental impacts

The local-scale impacts of land drainage on the natural environment

are extremely difficult to predict. This difficulty is the result of the complexity of inter-relationships which underlie the functioning of the natural environment. In the diagram, Figure 3.2, the direct local-scale environmental impacts of land drainage have been generalized under three headings; changes in the water content of soil, loss of water reservoirs, and impacts on vegetation and wildlife.

The primary purpose of land drainage is the removal of excess water from soil in order to improve its agricultural capability. The removal of excess gravitational water from the soil will result in changes in soil properties such as availability of capillary water, soil temperature, and soil aeration, all of which are beneficial to agriculture. When excess gravitational water is removed from a soil by drainage a lowering of the local ground-water table may occur and be reflected in water levels in wells and in some ponds. Therefore a reduction in the water content of the soil will result in changes in soil properties as well as possible lowering of the local ground-water table.

A second important impact of land drainage on the natural environment involves the loss of water reservoirs. In addition to the loss of temporary water reservoirs in the soil as described above, the potentially serious impacts associated with drainage of wetlands must be considered. The loss of wetlands may involve impacts on ground water levels, water quality, the magnitude and timing of stream flows (i.e. stream hydrographs), and on vegetation and wildlife. In many instances wetlands are located in areas of ground-water discharge or recharge, and drainage of the area will result either in increased discharge or reduced recharge, and, in either case, the lowering of the local water table. Wetlands may play significant roles as pollution filters in maintaining water quality downstream. Changes

in downstream water quality associated with wetland drainage may involve increases in the concentrations of stream nutrients and effects on various forms of aquatic life, including fish. Drainage of wetlands may adversely effect both the annual and storm hydrographs of streamflow. On an annual basis it is often suggested that wetlands reduce high flows and increase the low flows by storing water during spring and subsequently releasing flow during summer and fall. The hydrographs of individual storm events are affected in a similar manner with peaks being reduced as the water is stored and then released gradually. In both cases drainage of wetlands might be expected to result in increased magnitudes of flood flows and reduced low flows. The loss of water reservoirs associated with the drainage of wetlands may also have some impacts on vegetation and wildlife. Where the drainage results in a lowering of the water table vegetation may be affected both in terms of growth rates and changes in species composition. These changes along with the removal of open water result in the destruction or alteration of habitats for various forms of wildlife including waterfowl.

A final impact of land drainage on the natural environment involves the direct effects of construction on vegetation and wildlife. Construction of drainage works normally involves the use of heavy equipment which requires a strip to be cleared through woodlots through which the drain passes. The swathes cut through woodlots may result in the destruction of valuable timber and of wildlife habitats. The construction process also exposes bare soil to erosion and results in increased sediment loads in streams. The removal of vegetation may also result in significant changes in water temperatures which can affect various forms of aquatic life. The final dimension of the impact of drainage on vegetation and wildlife is related to the possible connection between the natural ecosystem and its stability,

and the risk that ecological disruption may become greater.

In concluding this brief overview of the impacts of drainage on the natural environment, it is important to recognize that one would not expect to find all the various impacts in every case. However, the far-reaching potential impacts of various activities, such as the use of stream water and ground water, fur-trapping, recreation, and lumbering, requires that the environmental consequences be given careful consideration.

(c) Non-agricultural land uses

An area which has received little attention concerns the impacts of land drainage, originally undertaken for agricultural purposes, on non-agricultural land uses. Of particular concern in Ontario is land use for urban development, recreation, conservation, forestry, and trapping. Drainage which benefits agriculture may either enhance or harm other uses within the drain's watershed; and it may change the competitive position of the various uses such that the areas they occupy undergo relative gains or losses. Beyond this very general statement, one can only give examples of possible impacts in the absence of evidence.

Concerning urban land, agricultural drainage might have welcomed or unwelcomed impacts. On the positive side, drainage channels might permit unwanted water from nearby urban land to dissipate. In turn, of course, this could be detrimental to agriculture if the drains, designed for a limited farming area, became overloaded with "urban" water. Another affect of drainage would be to give agricultural land a new potential for urban development. The removal of water might be all that is required to make the land saleable to prospective urban purchasers. Many other hypothetical examples of this type could be listed, although the probability of their occurence in Ontario is unknown.

With recreation, conservation, trapping and forest land, too, the affects of agricultural drainage may be positive or negative. Drain construction may destroy wetlands and the habitats of wildlife used for trapping, hunting, and scientific observation. On the other hand, drainage might improve the health of trees and create a better habitat for animals, birds and fish. Again there are few generalizing principles with which to speculate, and very few documented examples. Any investigation of these impacts must be on a fairly ad hoc basis. In this research, some evidence relative to the problem was obtained from the farm questionnaires, and some was gathered in special field projects.

3.3 Large-Scale Impacts

(a) agricultural and non-agricultural land uses

At the large scale (e.g. the Province) the aggregate effects of local drainage impacts give rise to a different set of relationships from those evident at the local scale (compare figures 3.2 and 3.3). Furthermore, practically no scientific attempts have been made to measure these effects, partly because the data required for such a task are highly unreliable or completely missing. This research makes little attempt to really measure the large-scale impacts, but it is important to be aware of their probable nature, particularly since this relates to general government policy-making, and could relate to changes in the land drainage legislation.

Little can be said about the large-scale impacts on non-agricultural land use, except to expand the comments made in section 3.2 (c) to recognize that the quantities and qualities of land for recreation, urban purposes, conservation, trapping, and forestry can be affected by the amount of

agricultural land drainage. For agriculture, the relationships can be formulated more specifically. Generally, one expects drainage installation to lead to greater agricultural productivity and some change in the qantities and types of farm inputs. This affects the supply of agricultural products, the demand for inputs, and all industries and businesses connected with agriculture. The normal expectation is for increased production to lead to greater food supplies, lower prices for food, greater demands for agricultural inputs, and a general stimulation of many agriculture-related businesses. At the same time, however, lower food prices produce lower aggregate farm incomes in spite of higher production. This is explained by the fact that the demand for food is strongly price inelastic. As stated above, however, it is very difficult to measure these large-scale effects, particularly since price and income levels are affected by federal and provincial policies on farm and food subsidies, imports, and exports.

(b) environmental impacts

At the large-scale level the impacts of drainage on the natural environment are quite similar to those discussed at the local scale. While many of the potential impacts discussed at the local scale may seem minor when viewed for a single drain, at the large scale cumulative effects of impacts from smaller drains may become more serious. For example, the loss of small wetlands as wildlife habitats may not seem important until, on a large scale, the total area of wetland has been drastically reduced. A similar case might be made from the effects of wetland drainage on the stream hydrograph. The local stream flow patterns may not be seriously affected by the drainage of a single small wetland; but the cumulative effect downstream of the drainage of numerous small wetlands in the headwaters of the drainage system may produce serious downstream flooding.

The environmental impacts detailed in the diagram, Figure 3.3, are intended to represent the cumulative effects of many small drainage projects when viewed at a large scale. The primary environmental impacts of land drainage result in changes in the hydrology, soils, vegetation and wildlife of an area. The impacts may result directly from the construction of drainage works or indirectly through the loss of wetlands and the problems associated with the loss of water reservoirs. Ultimately these impacts may result in alteration of an area's ecological stability, and other major environmental characteristics.

3.4 Summary

The conceptualization of the impacts of land drainage, as indicated in Figures 3.1, 3.2, and 3.3, proved of great value in the design of this research project. It provided the researchers with general guidelines for deciding what data and relationships to look for. It also clarified those areas which could not be examined within the limitations of this project, but which should be recognized as important. As is apparent in the following chapters, this study centres on the analysis of local-scale impacts.

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Chapter 4

METHODOLOGY FOR DRAIN ANALYSIS

4.1 Introduction

In order to provide conclusions that might be "typical" of the province as a whole most of the field research fell within a higly routinized investigation of drains within a sample of townships. The methods for selecting townships, drains, and properties are described in sections 4.2 - 4.5, while development of the standard property-level questionnaires is outlined in 4.6. The remaining sections describe a variety of other procedures used in the research.

4.2 Selection of Sample Townships

The number and location of townships selected for detailed study reflected an attempt to investigate a full variety of drainage and related conditions in the Province. Specific criteria considered in the selection process included the following:

(1) physiographic patterns and soil conditions.

An attempt was made to include a full variety of physiographic conditions, ranging from poorly-drained clay and muck flatlands through to well-drained uplands. Many soil types were to be included (e.g. muck, clay, loam, sand), with a particular effort to select townships with homogeneous soil conditions in order to simplify the selection of drains and the comparison of townships.

(2) climatic conditions.

The length of growing season, annual water-balance situation, and amount of growing-season precipitation vary considerably

across the Province. The selection process attempted to ensure that a broad variety of conditions was represented.

(3) land use.

Significant variation occurs across the Province not only with respect to agricultural land use but also urban, recreational, and conservation land uses. The selection procedure attempted to include townships representing variations in all of these types. Special consideration was given to including areas where conflicts among land-use types resulting from land drainage were present or likely. Areas of particularly rapid and recent change in agricultural land use were also included.

(4) watershed hydrology.

The hydrological characteristics of particular concern were the degree of stream maturity (e.g. extent of channel integration) and function as a headwaters region. Areas which varied in their functions as headwaters regions (i.e. water resevoirs) were selected because it was felt that the artificial drainage of natural resevoirs might create problems not present in down-stream areas. Also, areas with poorly-integrated natural drainage systems and associated wetlands were chosen for comparison with "better drained" regions. It was felt that wetlands were particularly significant because of potential land-use conflicts.

(5) character of drainage expenditure.

As indicated in Chapter 2, the amount and type (i.e. municipal vs. tile) of Government drainage expenditure varies greatly across the Province. Also, the extent of grants (e.g. one-third vs. two-thirds) is variable according to location. The townships were

selected to include a wide variety of expenditure conditions. Finally, an attempt was made to select areas with varying rates of change in recent expenditures.

(6) availability of special reports.

Preference was given to selecting areas for which useful reports had been prepared (e.g. Conservation Authority reports, briefs to the Select Committee on Land Drainage, planning studies, etc.).

(7) location within Ontario.

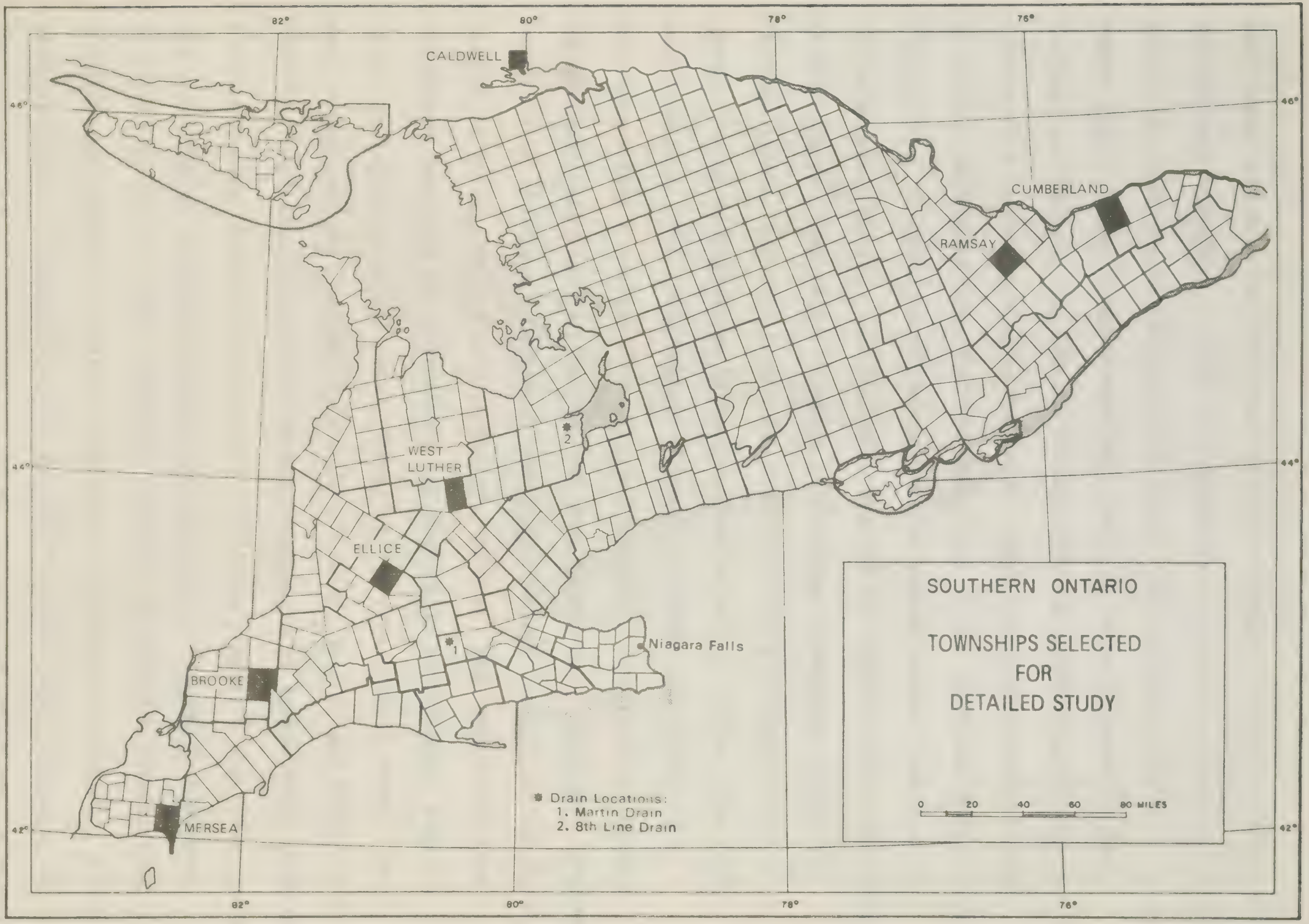
An attempt was made to include townships well distributed across the Province (e.g. Eastern Ontario, Southwestern Ontario, etc.).

(8) degree of cooperation of local officials.

Preference was given to areas where the local officials (e.g. township clerk) seemed to be particularly willing to assist with the research project.

Seven townships were selected for investigation (fig. 4.1), and together they represent a broad variety of conditions. Brooke (Lambton County) is typical of those areas in Southwestern Ontario with a long history of extensive drainage of flat-lying, mainly clay soils, a long growing season, and highly productive agriculture. Areas like Brooke were drained at the time of original settlement (see Des Rivieres, 1971) and have required continual and extensive drain construction and maintenance ever since. Mersea (Essex County), like Brooke, has highly productive agricultural land use, but soil conditions and cropping patterns are quite different. Soils tend to be sandy-loams, and farms specialize in vegetable production. Irrigation at dry times of the year is much more common than in most other parts of Ontario. The township also presents the possibility of agricultural-urban land-use conflicts around the town of Leamington. Ellice (Perth County) has experienced

Figure 4.1


SOUTHERN ONTARIO
TOWNSHIPS SELECTED
FOR
DETAILED STUDY
0
20
40
60
80 MILES
CALDWELL
CUMBERLAND
RAMSAY
WEST
LUTHER
ELLICE
BROOKE
MERSEA
Niagara Falls
1
2
Drain Locations:
1. Martin Drain
2. 8th Line Drain
82°
80°
78°
76°
46°
44°
42°

very large increases in expenditure on outlet drainage in the past five years, and has been undergoing a shift in agriculture to cash crop production. The soils tend to be medium-textured clay loams. The township occupies a headwaters region (Upper Thames watershed), which may make large-scale land drainage particularly significant if such drainage should lead to the depletion of a natural watershed reservoir. West Luther (Wellington County) is another headwaters area that has seen large recent increases in drainage expenditure. It has a significantly shorter growing season than townships in southwestern Ontario, and has never reached the agricultural productivity of that region. But recent interest in drainage, encouraged by special drainage grants, has made it and the surrounding Grey-Wellington region appear to have frontier-like drainage characteristics. At the same time, much land (e.g., the Luther Marsh) remains undrained, and serves as an important wildlife habitat. The possibility exists for conflicts between agriculturalists, conservationists, and recreationists. Cumberland (Regional Municipality of Ottawa - Carleton) and Ramsay (Lanark County) contain large amounts of poorly-drained land in Eastern Ontario. This region has been undergoing increases in productivity and changes in agricultural land use (e.g., increases in hybrid corn) throughout the past several years. As in West Luther, the possibility of land-use conflicts exists, and sub-optimum climatic conditions place limits on the development of agricultural productivity. A recent report (TOPECON Group Limited, 1971) has suggested that some drainage expenditures in eastern Ontario are uneconomic. Caldwell (Nipissing District) is one of a small number of townships in Northern Ontario with a significant amount of drainage expenditure. Like Eastern Ontario, a few scattered parts of Northern Ontario exhibit "frontier-like" drainage construction, with new drains being built in the hopes of stimulating agricultural

production.

4.3 Background Information on Sample Townships

Once the seven sample townships had been selected for detailed study, an intensive search of background information for each was undertaken. In addition to providing the best possible general description of each township prior to field research, the information was used in the selection of sample drains and properties. Once assembled, the township-level information (maps, reports, summaries, etc.,) was incorporated into township files for future reference. Each file contained the following types of information:

Physical Background

(1) Geomorphology:

-- description of geology and major landforms
-- natural drainage pattern
-- topographic maps

(2) Soils:

-- soil survey report and map
-- summary of major soil types
-- calculated percentages of major soil types
-- soil profile characteristics

(3) Climate and Hydrology:

-- temperature, precipitation and snowfall normals (30-year) for each month
-- growing season length and extremes
-- precipitation in growing season
-- annual water balance (calculation and graph)
-- annual hydrograph

(4) Biogeography:

-- natural vegetation (historical record from surveyors reports and present situation from conservation and other reports)
-- wildlife (mainly from A.R.D.A. maps of wildlife capability)

Settlement

(1) History of Settlement (from historical atlases, Agricultural Commission Report, 1881, Censuses of Canada 1861-1971)

(2) Current Situation (from map and air photograph interpretation and contemporary reports)

Agriculture

(1) Production Data (censuses of agriculture)

(2) Land Use (from A.R.D.A. maps, air photographs and other sources)

Artificial Drainage

(1) History of drainage, 1920-72 (provincial records)

(2) Map of all current municipal drains

Other Materials

(1) Large-scale air-photo mosaics (4 inches equal 1 mile)

(2) Special reports (e.g., Conservation Authority reports) and maps

4.4 Selection of Sample Drains Within Townships

Formal procedures for selecting drains for detailed analysis were adopted in order to ensure comparability of research results from township to township and to ensure that a full variety of situations was encountered. Occasionally deviations from the procedures were necessary due to a township's unique characteristics (e.g., when a township had too few drainage projects in a particular year from which to draw a sample), but such cases were infrequent.

It was decided to study only those drains which had been constructed or modified during the period 1965-66 to 1969-70. This was to avoid drains where impacts had occurred too long ago to be measured or remembered, or where the full impacts of construction are yet to be felt. All drainage projects in the five-year period were listed, and a random sample of four drains for each year was selected, yielding a total of 20 drains. The 20 drains and their watersheds were then located on a large-scale map (1 inch equals 1/2 mile) over which transparent maps of other features, such as

soil type, could be laid. Using this map and other data (such as the engineering reports) five sample drains were selected from the 20 for detailed field study. The five were selected to ensure that a variety of conditions was represented. The criteria used in the selection included:

(1) soil types of the land drained,

(2) type of construction (e.g., new drain versus maintenance),

(3) type of drain network (e.g., open, closed, extent of branching, etc.,),

(4) periodicity of maintenance of drain, (calculated from provincial records),

(5) number of property owners assessed, ← why, just to cut down sample data?

(6) age of drain,

(7) types of land use affected (e.g., wetlands, urban, cropland, etc.),

(8) location within the township. ← why, this should not be significant

4.5 Selection of Sample Properties Within Drains

As with the selection of sample drains, sample properties within drains were selected according to highly formalized procedures. Maps indicating all properties assessed (benefit and outlet) were prepared for each drain at a scale of 4 inches equals 1 mile (same scale as the air photo coverage). For drains with 32 properties or less, a sample of 8 properties was selected at random, with 6 of the properties being assessed "benefit" and 2 being assessed "outlet" only. This enabled the researchers to concentrate on farms benefitting from drainage, but to check some "outlet" farms to discover the full effects of drain construction. If the total number of properties exceeded 32, a 25 percent sample was selected, with the ratio of "benefit" to "outlet" properties remaining at 3:1. In addition

to sample farms, 10 percent of all "urban" properties (i.e. small residential lots) were selected for investigation. If a drain had 8 or fewer farms assessed, all were included for study. As a result of the sampling procedure each township had approximately 40 properties for detailed study, although the total number of property owners might be significantly less due to multi-property ownership. Prior to interviews with the landowners, maps of land-use and field boundaries, as interpreted from aerial photographs, were prepared for each property.

4.6 Design of the Property-Level Questionnaire

The owner or manager of each sample property was asked a large number of questions (127) included in the project's questionnaire (Appendix 2). The questionnaire was designed to obtain information of the highest degree of accuracy possible for this type of survey concerning the full range of drain-construction impacts. Analysis of the questionnaire data was to be used to calculate agricultural benefit-cost ratios, "environmental" impacts, and many other types of indicaters. Development of the final version of the questionnaire required several weeks of trial field testing and modification.

4.7 Interviews and Correspondence

In order to gain further insights into the full benefits and costs of land drainage activity the research team undertook a large number of interviews on a township, regional, and provincial scale. At the township level interviews included township clerks and drainage commissioners. At the regional level interviews included representatives of regional offices of the Ministry of Natural Resources, drainage engineers, and agricultural

representatives. At the provincial scale interviews included representatives of the Canada Wildlife Service, the Queens Park Offices of the Ministry of Natural Resources, and various universities; the Provincial Drainage Referee; and other interested individuals. In all cases the researchers attempted to approach persons who had first-hand experience relating to agricultural drainage projects.

In addition to the interviews conducted within the Province of Ontario, correspondence was initiated with individuals in other parts of Canada and in other countries. The individuals who were contacted included representatives of various government agencies concerned with land drainage programmes and researchers who have published relevant material.

A list of the individuals interviewed and/or with whom which correspondence was initiated is presented in Appendix 1.

4.8 Other Field Surveys

In an effort to obtain information relating to specific problems associated with drainage activity several field surveys were undertaken. With respect to environmental impacts of land drainage several cases of anticipated impacts were identified and visited in the field. Two such cases--The Stroud Drain in Simcoe County and the Martin Drain in Norfolk County--were studied in detail. These studies included farm-level interviews and field surveys. In an attempt to collect data relating to the life cycle of a drain field surveys of drains of varying age were undertaken in West Luther Township. The analysis of urban land-use conflicts included an intensive probe of a problem situation on the outskirts of the City of Niagara Falls.

4.9 Analysis of Questionnaire Data

On completion of the property-level interviews the questionnaire data were transferred to summary sheets. Summary statistics were then calculated by drain and by township. These statistics were arithmetic means, sums, or modes, depending on the variable. Also, verbal summaries of qualitative data (e.g., data concerning changes in crop rotation) were made.

Additional calculations were made to derive benefit-cost ratios, procedures which are described in Chapter 5.

References

DES RIVIERES, D. R. (1971). The Draining of the Great Enniskillen Swamp, Lambton County, Ontario, M.A. Research Paper, York University, Toronto.

TOPECON GROUP LTD. (S. E. BROOKS) (1971). A Study of the Agricultural Drainage Outlet Assistance Program in Eastern Ontario, prepared for the A.R.D.A. Branch, Ontario Department of Agriculture and Food.

Chapter 5

AGRICULTURAL BENEFITS AND COSTS

5.1 The Questionnaire Data

The property-level questionnaires provided data with which to calculate the full range of economic benefits and costs resulting from drain construction (Sec. 4.6, Appendix 2). It should be emphasized, however, that the data were seldom derived from careful measurement or record-keeping, and that they represent only farmers' opinions or estimates. The quality of these estimates and of other farmer responses vary greatly from property to property, so that the data are not only inaccurate but of varying credibility. Nevertheless, no alternative forms of measurement were possible within the limited time period of the project, and the use of such questionnaire methods has become an accepted practice in similar agricultural surveys.

The total number of properties studied in each township was about 40 (see Section 4.5), averaging 8 properties per drain. In Brooke and Ellice Townships, 6 rather than the usual 5 drains were examined to permit the analysis of a broader range of conditions. The number of property owners interviewed was sometimes significantly less than the number of properties since individual farmers often owned more than one of the sample properties. Everywhere the interviewers were met by farmers willing to arrange for long and detailed questioning. The researchers were satisfied that the farmer survey proceeded successfully.

5.2 Benefit-Cost Calculations

The primary objective of the calculations was to determine the benefit-

cost ratios for all drains. The benefit-cost ratio in this case was obtained by dividing the total cost of the drain (irrespective of subsidies) into the present value of all current and future net returns from agriculture which would not have occurred without the drain construction. In other words, the net value of added benefits due to drain construction was divided by the cost of such construction to yield the benefit-cost ratio. Subsidies were ignored in the calculations, although the ratios could easily be modified to take them into account.* Ratios less than 1.0 would indicate that the benefits are outweighed by the costs; those of 1.0 reflect that benefits are equalled by costs; and those greater than 1.0 indicate that benefits outweigh the costs. Normally it is hoped that ratios will exceed 1.0. This use of benefit-cost analysis is a standard economic technique that has been applied to agricultural drain analyses in other Canadian studies (TOPECON Group Ltd., 1971; Rigaux and Singh, 1973).

The present value of current and future benefits (the numerator of the ratio) is calculated by determining the average annual net increase in agricultural income, and adding together the present value of all such annual incomes over the time period for which the benefits are expected. The formula for the present value of any future annual income is $V = \frac{A}{(1+i)^n}$, where V = the present value of the future income, A = the average increase in net annual income, i = an appropriate interest or discount rate, and n = the number of years into the future of the income (Edge, 1960, p. 25).

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*For example, if the subsidy was 2/3, the ratio could be multiplied by 3 to produce a figure which considered only the payment made by the farmer. Similarly, with a subsidy of 1/3 the ratio could be multiplied by 3/2.

Calculations for this study were based on a number of assumptions:

(a) only agricultural benefits are considered. Any benefits accruing to roads or other land uses are ignored.

(b) the future annual incomes due to drain construction will remain the same as those reported for the present. Even though considerable variations from year to year are bound to occur because of varying weather conditions, and even though the increases reported to date may be abnormal, it is assumed that future increases will not differ from current ones.

(c) the increases in production due to drain construction will cease at the end of the drain's life cycle (i.e., when it becomes defective). The nature of the relationship between drain age and increases in agricultural production is not well understood. For simplicity this study assumes that the increases remain constant throughout the life of the drain until it becomes defective, at which time the increases disappear.

(d) an appropriate range of interest rates is 6-10 percent. This range would seem to span the rates at which the Government is able to borrow money.

(e) an appropriate range of lifetimes for the drains is 5-20 years. Estimates of lifetimes were obtained from personal communications and public reports prepared by a number of drainage engineers. For example, W. McDowall (Ottawa) indicates a minimum lifetime for a drain in Rubicon Sand at 5 years, with more normal lifetimes in Eastern Ontario extending to 20 years. D. Rogerson reports 7-8 years for Wyndham Twp., Norfolk Co.; and H. Todgam suggests 15-20 years for the Chatham area.

(f) no secondary benefits to sectors of the economy related to agriculture are considered. For example, increased purchases of farm inputs are not counted as benefits accruing to the project.

Following these assumptions, calculations of present values and corresponding benefit-cost ratios have been undertaken separately for interest rates of 6, 8, and 10 percent, and for drain lifetimes of 5, 12, and 20 years. It is felt that this range of values permits a proper evaluation of any drain in the sample.

Construction costs for the sample properties in the drain are based on the actual total cost of the drain and the engineer's estimate (in the engineer's report) of the proportion of that cost which should be paid by those properties. It will be remembered that the samples normally included three times as many "benefit" properties as properties assessed only for "outlet." So the "outlet" properties, which almost always report no increases in production, are under-represented, which could lead to benefit-cost ratios which are unrealistically high. On the other hand, outlet assessments are normally very small, almost insignificant compared to "benefit" assessments. When this is the case and when the engineer uses a system of distributing assessments which bears a strong relationship to probable benefits, the cost figures and corresponding benefit-cost ratios in this study are fair and appropriate. In some cases calculations of this type were unnecessary since the sample includes all properties subject to an assessment.

Increases in farm income due to drain construction are sometimes difficult to distinguish from those accruing to other factors, such as changes in seed or equipment. So although the questionnaire was designed to provide for this distinction, the data still contain many uncertainties. In the calculation of increased benefits the basic procedure was to determine the average annual

value of drainage-related increases in production whether or not the increased production was actually sold. The researchers did not wish to ask farmers to reveal actual dollar-value changes in net income since it was felt that this would be an invasion of privacy. But specific data on production changes and general percentage estimates of net income change, which could be cross-referenced with calculated changes, were obtained.

Increases in production tended to be a result of increases in yield, changes in land use, changes in rotation systems which permitted more lucrative crops to be grown more of the time, or changes in animal production. Another form of change, which was included in the calculation of changes in net income, was the value of human labour saved when less time was required for farm work (see example below). Associated with the changes in gross income were a number of changes in associated costs. Besides paying for the drain, a number of other input costs were incurred. These included the cost of new equipment, fertilizer, and livestock. A very significant added cost occurred when field underdrainage was installed to take advantage of the new outlet drain. This presented a serious accounting problem since the life of field underdrainage systems tends to be much longer than that of outlet drains. Consequently, the cost of field underdrainage was calculated, on an annual basis, as the yearly payment required to pay the total cost of the installation over 40 years at 6% interest. Forty years was chosen since this approximates many estimates of the effective life of field underdrainage. A shorter time period was not chosen (e.g., the lifetime of the outlet drain) since this would assume that all benefits of the field drainage were subsumed before the end of its actual lifetime. At the same time it is recognized that farmers do pay for field underdrainage in a shorter period than 40 years, so that their annual costs would be somewhat higher than those assumed in this analysis.

Consequently, this study assumes higher incomes during the first few years following a project and lower incomes during later years than farmers in the real world would probably experience. The 6 percent interest rate was chosen since it occupies a position midway between normal bank-loan rates and the special 4% rate normally obtainable through the Tile Drainage Act.

Prices and costs used in the calculation of increased net income were county averages for the years 1969-72 as derived from statistics published by the Ontario Department of Food and Agriculture (Ontario Department of Agriculture and Food, 1969-72). Prices for items not included in the usual publications were obtained directly from the Department of Food and Agriculture or marketing boards.

The following example (the Munro drain in Brooke Twp.) will help illustrate the way in which values for increases in income were derived (see Table 5.1). Since the completion of the project, most farmers in the sample of seven have experienced little change in production. An important exception, however, is one farmer who has installed new tile under 20 acres at a total cost of $3,420. The annual equivalent of this cost, calculated according to the procedure described above, is $227. Some land-use and yield change has occurred on the sample properties, although the bulk of the change is on the newly-tiled land where former pasture has been switched to grain. The difference in the market value of current production over the old is calculated separately for each farm and summed to yield a net increase of $2,703. Where changes in crop rotation are involved annual values of production averaged over three or four years (whatever is the length of the rotation cycle) are compared for the new and old rotations to derive increases in the value of average gross annual production. Increased production has required increased costs in addition to field

underdrainage. Culverts have had to be installed, a granary constructed, and more fertilizer purchased. The annual value of these added costs, calculated by spreading the costs over the life of each item at six per-cent interest, is \$392. Thus, the average annual increase in <u>net</u> income, irrespective of labour costs, is \$2,703 - (\$392 + \$227) = \$2,084. Less labour has been required following completion of the project, since farmers report an aggregate saving of four days. At \$20.00 per day, the value of the saving is calculated at \$80.00. Thus, the final estimate of the average annual increase in net income is \$2,084 + \$80 = \$2,164.

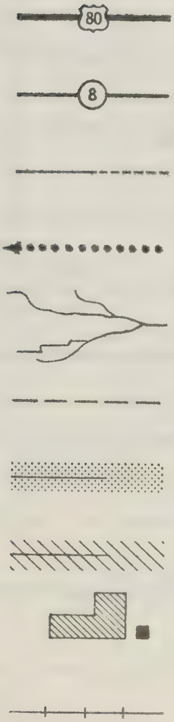
Note that significant differences can occur between the actual change in income experienced by farmers and the estimates calculated by the above procedures. For example, if the labour saved is the farmer's own time, he will gain no financial return. Also, the cost of the tile might be borne in five years rather than 40. But the researchers hold that the procedures used are essential to produce comprehensive estimates of the full benefits and costs over the life of the drains even if these statistics differ from particular farmers' experiences in the short run. In many cases, nevertheless, the estimated benefits appear to bear a close resemblance to those reported by property owners.

5.3 Results of the Analysis

Figures 5.1 - 5.7 are township maps indicating the locations of the 37 drains selected for detailed analysis. Tables 5.1 - 5.7 are corresponding compilations of relevant production and costs-returns data for the sample drains. Table 5.8 lists the benefit-cost ratios for each drain.

The agricultural benefits of draining land, as described by Biliski (1972) and others, and as generally assumed, are evident throughout the

LEGEND



Kings highway

County road

Other road

Drain

River

Urban corporate limit

Township boundary

County boundary

Populated area

Railway

Figure 5.1

BROOKE TOWNSHIP

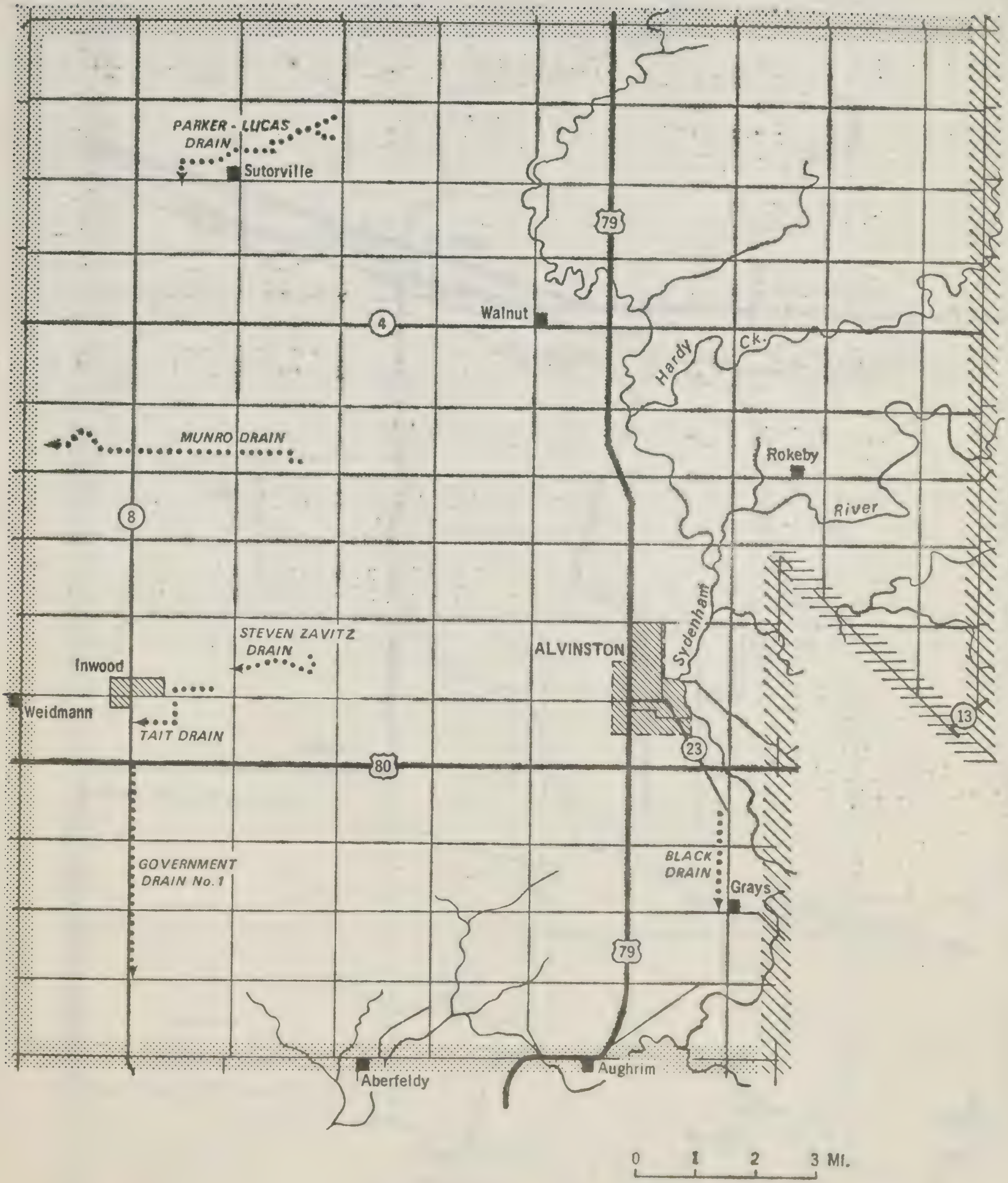


Figure 5.2

CALDWELL TOWNSHIP

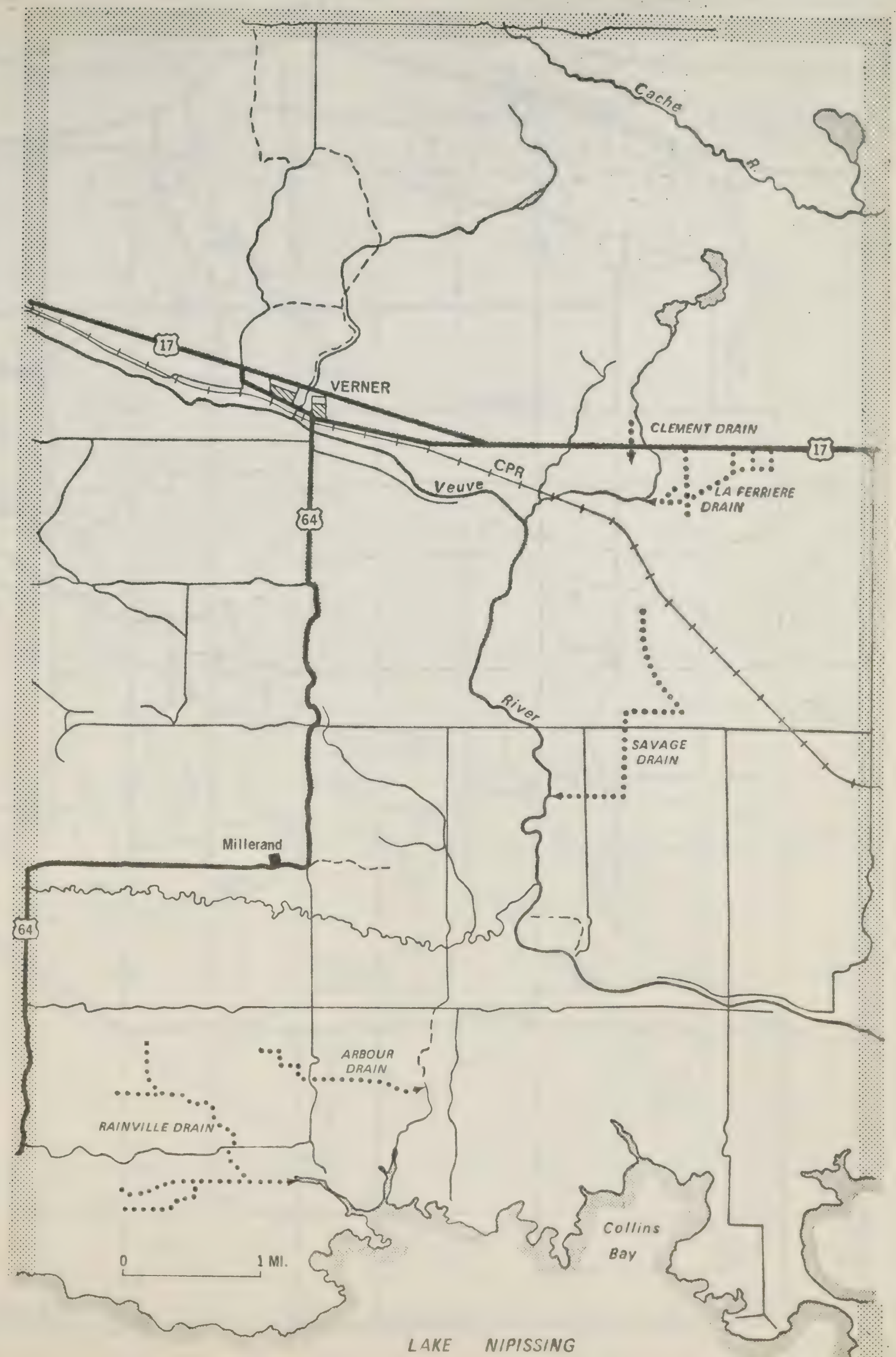


Figure 5.3

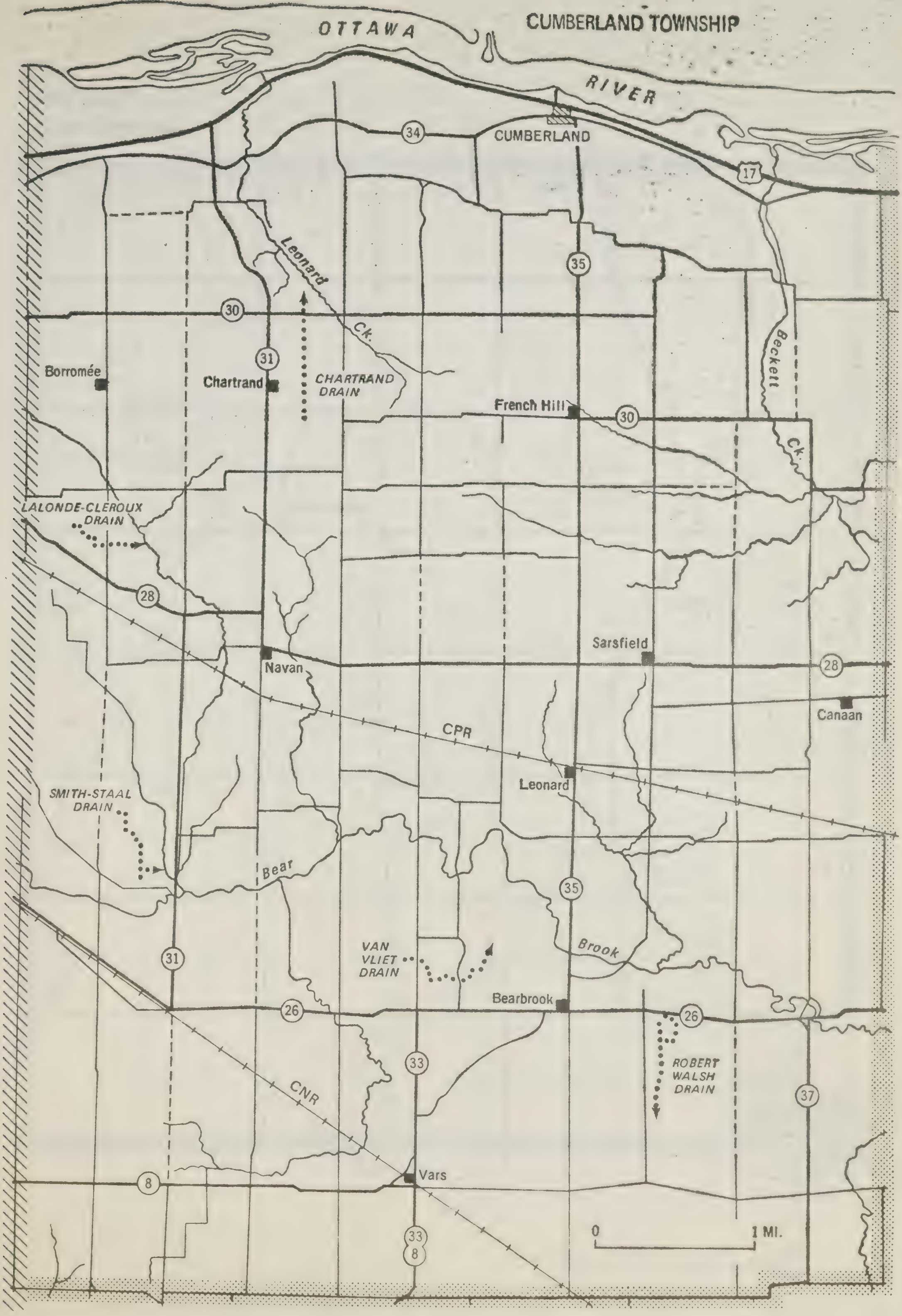

CUMBERLAND TOWNSHIP
OTTAWA
RIVER
CUMBERLAND
34
17
35
30
31
Leonard
Ck.
Borromée
Chartrand
CHARTRAND
DRAIN
French Hill
Beckett
Ck.
LALONDE-CLEROUX
DRAIN
28
Navan
Sarsfield
Canaan
CPR
Leonard
SMITH-STAAL
DRAIN
Bear
Brook
VAN
VLIET
DRAIN
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Figure 5.4

ELLICE TOWNSHIP

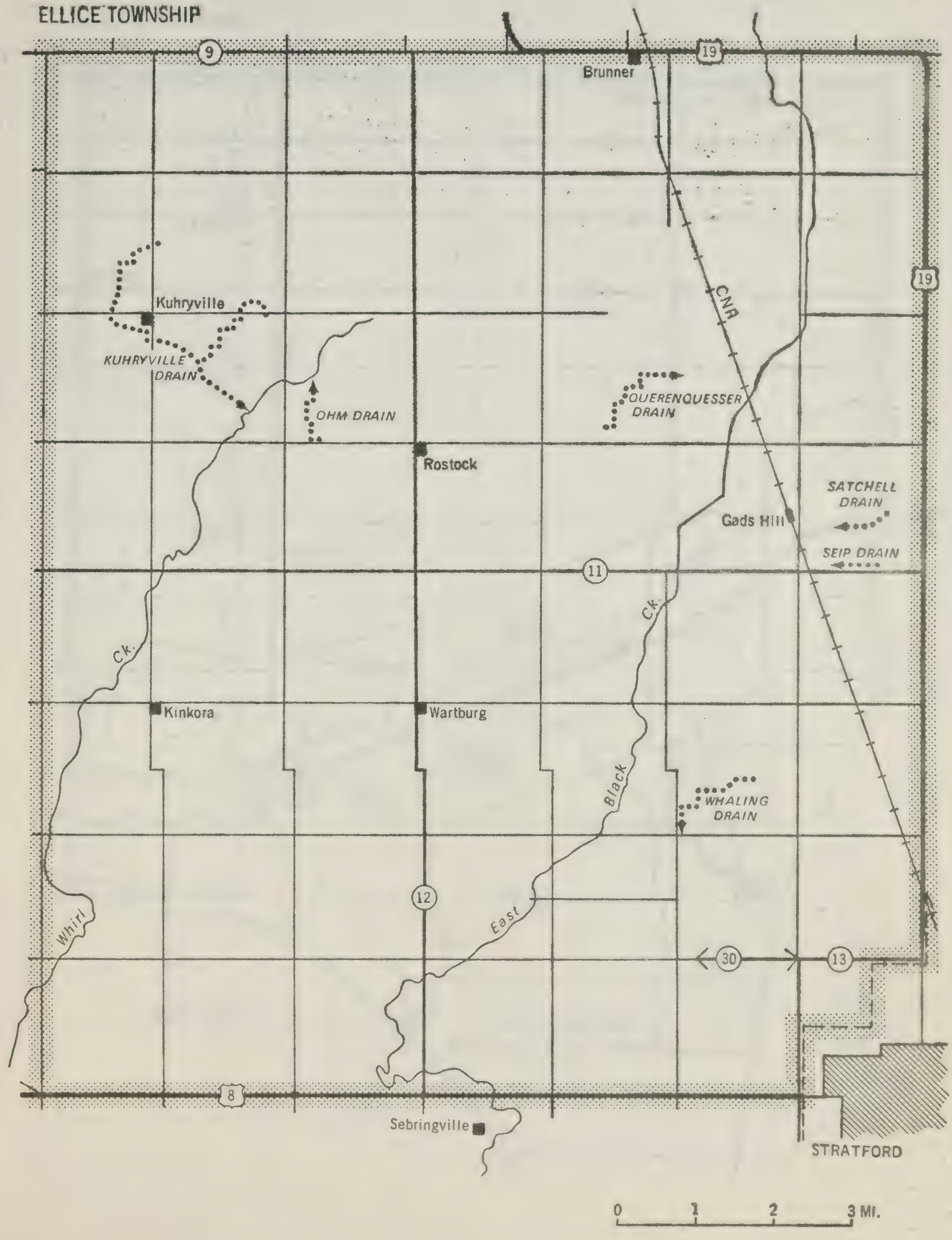

Figure 5.5.

MERSEA TOWNSHIP

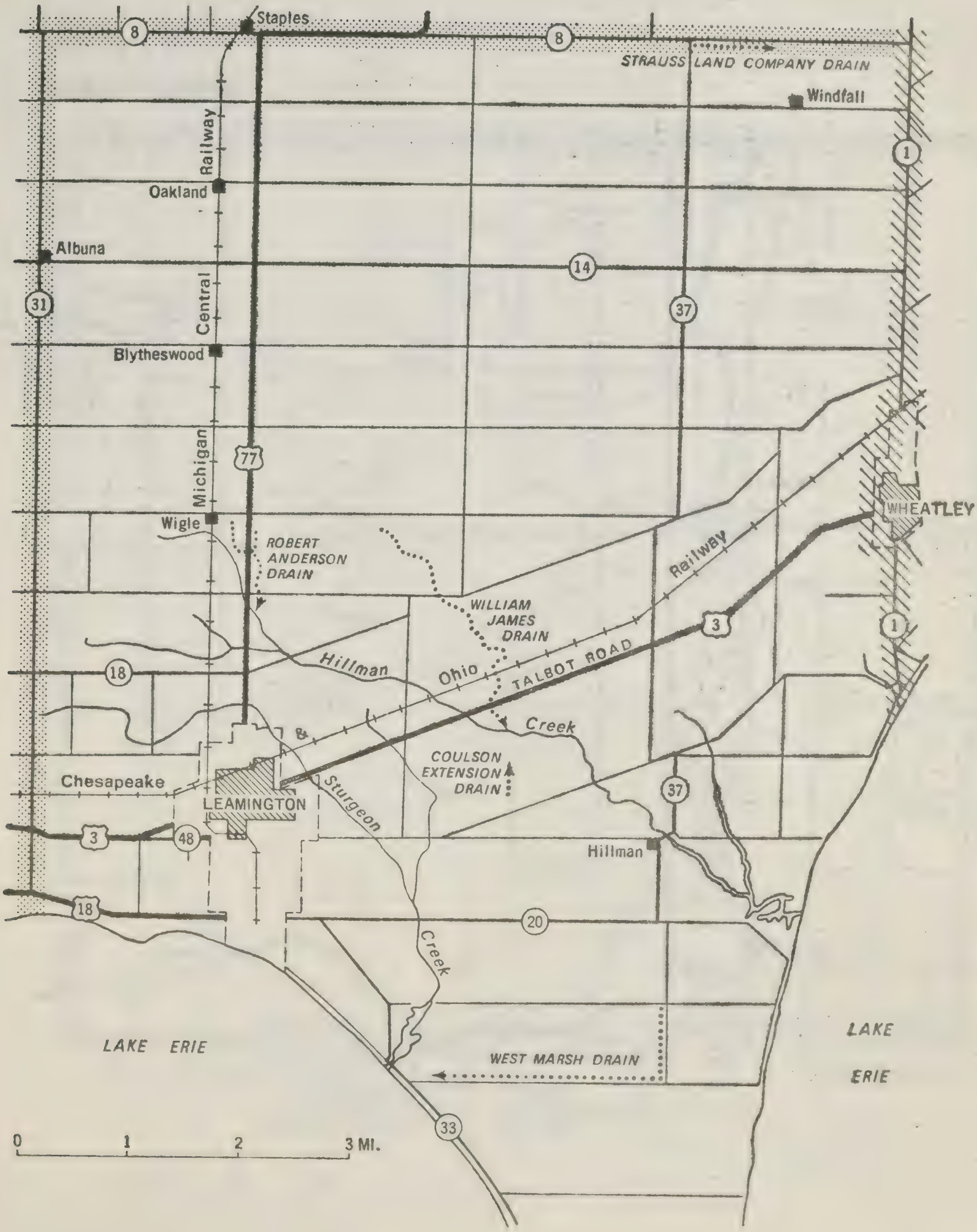

Figure 5.6

RAMSAY TOWNSHIP

Figure 5.7

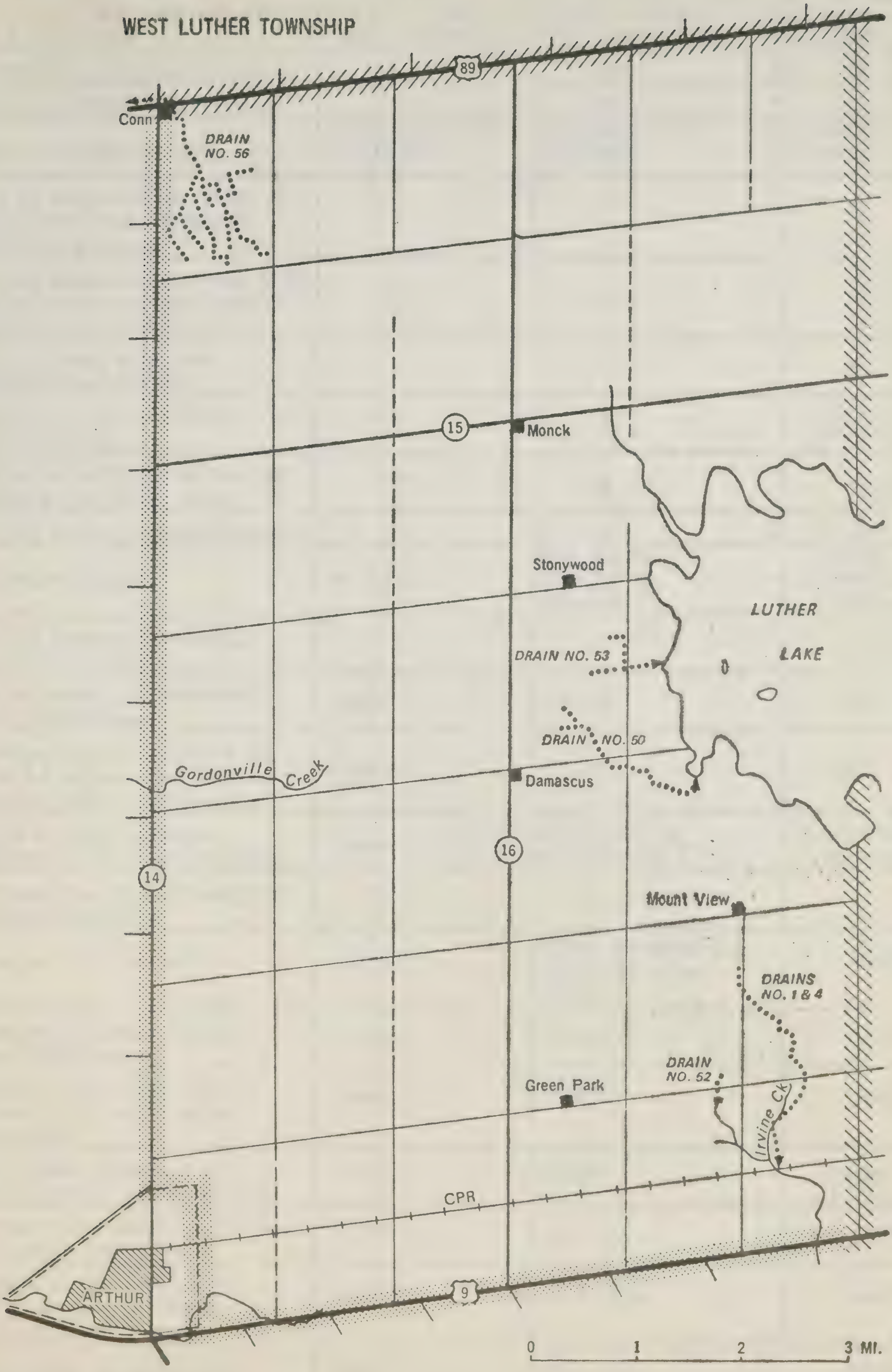
WEST LUTHER TOWNSHIP
89
Conn
DRAIN
NO. 56
15
Monck
Stonywood
LUTHER
LAKE
DRAIN NO. 53
DRAIN NO. 50
Gordonville Creek
Damascus
16
14
Mount View
DRAINS
NO. 1 & 4
DRAIN
NO. 52
Green Park
Irvine Ck
CPR
ARTHUR
9
0
1
2
3 MI.

TABLE 5.1
Pg. 77

BROOKE TOWNSHIP	BLACK DRAIN	GOVERNMENT DRAIN NO. 1	MUNRO DRAIN
Soil conditions	Loam (Burford)	Clay (Brookston)	Clay (Brookston)
Total no. of property owners	3	27	20
No. of owners interviewed	3	8	7
Type of drain project	Replacing tile in old drain	Dredging old Channel	Dredging old Channel
No. of sample properties with field underdrainage prior to project	0	6	6
No. of sample properties with field underdrainage installation since project	0	0	1
No. of acres with new field underdrainage	0	0	20
Total cost of new field underdrainage	0	0	$3420
Farmer's estimate of no. of acres affected by drain	70	439	313
No. of acres assessed benefit	0	923	707
Land-use change	no change	Some switch from hay to soybeans	Slight change from pasture to grain
No. of farmers reporting increased yields	2	5	1
Market value of increased crop production	$273	$1425	$2703
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	none	$600	$539
Types of input changes besides field underdrainage	none	purchase more young cattle	culvert installation
Average no. of days earlier seeding possible	8	2	2
Changes in livestock	none	slight increase in no. of beef cattle	none
Changes in gross income from livestock	none	+ $1139	none
Increase in income due to change in feed sales or purchases	none	+ $1225	none
Net annual increase in farm income (calculated)	$273	$1400	$2164
Farmer's estimate of increase in income (mode)	1%	1 - 5%	0%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	never	>10 yrs.	never
Total cost of drain for sample properties	$2275	$10,012	$5,772

TABLE 5.1 (Cont'd) Pg. 78

BROOKE TOWNSHIP (cont'd)	Parker-Lucas Drain	Stephens-Zavitz Drain	Tait Drain
Soil conditions	clay (Brookston)	clay (Brookston)	clay (Brookston)
Total no. property owners	20	5	48 (8 agr'l)
No. of owners interviewed	8	5	10 (3 urban)
Type of drain project	dredging old channel	replace tile in old drain	dredging old channel
No. of sample properties with field underdrainage prior to project	6	1	5
No. of sample properties with field underdrainage installation since project	2	3	3
No. of acres with new field underdrainage	8	185	148
Total cost of new field underdrainage	$850	$34,000	$14,400
Farmer's estimate of no. of acres affected by drain	315	220	332
No. of acres assessed benefit	451	244	464
Land-use change	slight change in rotation	switch from small grains to corn and soybeans	switch from hay to grains, corn and soybeans
No. of farmers reporting increased yields	4	4	5
Market value of increased crop production	$1623	$7363	$3717
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	$3264	$2388	$1957
Types of input changes besides field underdrainage	a bit more fertilizer, purchase more beef cattle	a bit more fertilizer	purchase small pigs
Average no. of days earlier seeding possible	4	8	6
Changes in livestock	increase in beef cattle	slight increase in turkeys	increase in no. of pigs
Changes in gross income from livestock	+$5060	+$60	+$3555
Increase in income due to change in feed sales or purchases	+$691	+$3925	+$1754
Net annual increase in farm income (calculated)	$1797	$5085	$2830
Farmer's estimate of increase in income (mode)	0%	6 - 10%	1 - 5%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	6 - 10 yrs.	>10 yrs.	6 - 10 yrs.
Total cost of drain for sample properties	$9448	$13,780	$6726

CALDWELL TOWNSHIP	TABLE 5.2 Pg. 79 Arbour Drain	Clement Drain	La Ferriere Drain
Soil conditions	stony mixture	clay and silt	clay and silt
Total no. of property owners	4	4	9
No. of owners interviewed	3	4	5
Type of drain project	dredging old channel	new drain (tile)	dredging old channel
No. of sample properties with field underdrainage prior to project	0	0	0
No. of sample properties with field underdrainage installation since project	0	1	0
No. of acres with new field underdrainage	0	10	0
Total cost of new field underdrainage	0	$500	0
Farmer's estimate of no. of acres affected by drain	185	41	454
No. of acres assessed benefit	not available	not available	not available
Land-use change	none	none	slight pasture improvement
No. of farmers reporting increased yields	0	2	4
Market value of increased crop production	$120	$698	$ 1950
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	$10	$199	$1425
Types of input changes besides field underdrainage	short fence installed	purchase of cattle	purchase of cattle
Average no. of days earlier seeding possible	10	8	6
Changes in livestock	none	increase in no. of milk cows	increase in no. of milk cows
Changes in gross income from livestock	0	+$1000	+$3000
Increase in income due to change in feed sales or purchases	0	+$698	+$1800
Net annual increase in farm income (calculated)	$200	$801	$2000
Farmer's estimate of increase in income (mode)	1 - 5%	1 - 5%	<1%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	2 - 5	2 - 5	2 - 5
Total cost of drain for sample properties	$4654	$3960	$2,216

CALDWELL TOWNSHIP (con't)	TABLE 5.2 (Cont'd) Pg. 80 Rainville Drain	Savage Drain
Soil conditions	clay and silt	clay and silt
Total no. of property owners	8	6
No. of owners interviewed	8	5
Type of drain project	new drain	dredging old channel
No. of sample properties with field underdrainage prior to project	0	0
No. of sample properties with field underdrainage installation since project	0	0
No. of acres with new field underdrainage	0	0
Total cost of new field underdrainage	0	0
Farmer's estimate of no. of acres affected by drain	672	365
No. of acres assessed benefit	not available	not available
Land-use change	none	improvement of pasture
No. of farmers reporting increased yields	3	2
Market value of increased crop production	$931	$1737
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	$1197	$687
Types of input changes besides field underdrainage	fences, milk cows, more purchased feed	purchase of beef and milk cattle
Average no. of days earlier seeding possible	4	7
Changes in livestock	some increase in no. of milk cows, switch to beef	increases in beef and milk cattle
Changes in gross income from livestock	+$3700	+$1900
Increase in income due to change in feed sales or purchases	-$2836	+$1737
Net annual increase in farm income (calculated)	$931	$1917
Farmer's estimate of increase in income (mode)	0%	1 - 5%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	2 - 5	2 - 5
Total cost of drain for sample properties	$21,244	$4654

CUMBERLAND TOWNSHIP	TABLE 5.3 Pg. 81 Chartrand Drain	LaLonde-Clexoux Drain	Robert Walsh Drain
Soil conditions	clay (Bearbrook)	fine sandy-loams and clays	mainly fine-sand
Total no. of property owners	6	11	5
No. of owners interviewed	4	8	5
Type of drain project	dredging old channel	dredging old channel	dredging old channel
No. of sample properties with field underdrainage prior to project	1	0	0
No. of sample properties with field underdrainage installation since project	0	0	0
No. of acres with new field underdrainage	0	0	0
Total cost of new field underdrainage	0	0	0
Farmer's estimate of no. of acres affected by drain	271	53	141
No. of acres assessed benefit	227	54	157
Land-use change	slight switch from hay-grain to corn	slight increase in vegetables	slight pasture-hay improvement
No. of farmers reporting increased yields	2	2 (some declining yields)	2
Market value of increased crop production	$281	0	$1004
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	$237	0	$1461
Types of input changes besides field underdrainage	purchase milk cows	none	purchase more beef cattle + feed
Average no. of days earlier seeding possible	7	3	6
Changes in livestock	increase in milk cattle	none	increase in beef cattle and feed
Changes in gross income from livestock	+$1000	0	+ $2700
Increase in income due to change in feed sales or purchases	-$163	0	-$403
Net annual increase in farm income (calculated)	$680	0	$1084
Farmer's estimate of increase in income (mode)	1 - 5%	0%	(0) (1 - 5%)
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	never	never	never (2 - 5 yrs.)
Total cost of drain for sample properties	$1951	$1801	$8419

CUMBERLAND TOWNSHIP (con'd.)	TABLE 5.3 (Cont'd) Pg. 82 Smith-Staal Drain	Van Vliet Drain
Soil conditions	peat and clay	fine sand (Uplands)
Total no. of property owners	4	6
No. of owners interviewed	3	5
Type of drain project	new drain	dredging old channel
No. of sample properties with field underdrainage prior to project	0	0
No. of sample properties with field underdrainage installation since project	0	0
No. of acres with new field underdrainage	0	0
Total cost of new field underdrainage	0	0
Farmer's estimate of no. of acres affected by drain	115	47
No. of acres assessed benefit	154	103
Land-use change	some swamp switched to hay, hay to grain	none
No. of farmers reporting increased yields	0	1
Market value of increased crop production	0	$103
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	0	0
Types of input changes besides field underdrainage	none	none
Average no. of days earlier seeding possible	0	7
Changes in livestock	none	more horses
Changes in gross income from livestock	0	0
Increase in income due to change in feed sales or purchases	-$880	0
Net annual increase in farm income (calculated)	0	$103
Farmer's estimate of increase in income (mode)	0%	0%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	(never) (1yr.) (2-5 yrs.)	never
Total cost of drain for sample properties	$13,515	$3081

ELLICE TOWNSHIP	TABLE 5.4 Pg. 83 Kuhryville Drain	Ohm Drain	Quererquesser Drain
Soil conditions	silt-loam, some clay	clay (Perth)	silt-loam, muck and silt-clay
Total no. of property owners	24 (23 agr.)	5	6 (5 agr.
No. of owners interviewed	8	4	5
Type of drain project	dredging old channel	dredging old channel	dredging old channel
No. of sample properties with field underdrainage prior to project	5	3	2
No. of sample properties with field underdrainage installation since project	3	1	0
No. of acres with new field underdrainage	17.5	30	0
Total cost of new field underdrainage	$1690	$4500	0
Farmer's estimate of no. of acres affected by drain	505	85	207
No. of acres assessed benefit	580	74	305
Land-use change	no change	some switch from pasture to corn	pasture- hay improvement
No. of farmers reporting increased yields	3	4	2
Market value of increased crop production	$1070	$1520	$2439
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	$132	$799	$2821
Types of input changes besides field underdrainage	culvert, more beef cattle	more beef cattle	more cattle and purchased feed
Average no. of days earlier seeding possible	4	8	7
Changes in livestock	more beef cattle	more beef cattle	more beef and milk cattle
Changes in gross income from livestock	+$900	+$1102	+$6200
Increase in income due to change in feed sales or purchases	+$1000	+$1458	-$1321
Net annual increase in farm income (calculated)	$968	$1301	$2961
Farmer's estimate of increase in income (mode)	0%	(<1%) (1 - 5%)	1 - 5%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	6 - 10 yrs.	(2-5) (6-10) yrs.	6 - 10 yrs.
Total cost of drain for sample properties	$7868	$2632	$2534

ELLICE TOWNSHIP (con'd.)	TABLE 5.4 (Cont'd) Satchell Drain	Pg. 84 Siep Drain	Whaling Drain
Soil conditions	silt-loam (Brookston)	silt-loam (Brookston)	silt-loam (Brookston)
Total no. of property owners	2	6 (4 agr.)	4
No. of owners interviewed	2	5	4
Type of drain project	new drain	dredging old channel	dredging old channel
No. of sample properties with field underdrainage prior to project	1	2	3
No. of sample properties with field underdrainage installation since project	1	1	1
No. of acres with new field underdrainage	40	25	12
Total cost of new field underdrainage	$6500	$4000	$1800
Farmer's estimate of no. of acres affected by drain	57	118	152
No. of acres assessed benefit	100	93	216
Land-use change	none	none	none
No. of farmers reporting increased yields	1	1	1
Market value of increased crop production	$7890	$1305	$885
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	$6643	$266	$3927
Types of input changes besides field underdrainage	grainary	none	purchase more beef cattle
Average no. of days earlier seeding possible	15	7	2
Changes in livestock	more beef cattle and hogs	none	more beef catt[illegible] fewer hogs
Changes in gross income from livestock	+$8500	none	+$1000
Increase in income due to change in feed sales or purchases	0	0	0
Net annual increase in farm income (calculated)	$5747	$439	$458
Farmer's estimate of increase in income (mode)	0%	0%	0%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	6 - 10 yrs.	never	never
Total cost of drain for sample properties	$2165	$654	$819

MERSEA TOWNSHIP	TABLE 5.5 Pg. 85 R. Anderson Drain	Coulson Drain	W. James Drain
Soil conditions	sandy-loam (Berrien)	sandy-loam (Berrien)	sandy-loam (Berrien)
Total no. of property owners	68 (41 agr.)	6	36
No. of owners interviewed	16	6	11
Type of drain project	extension and tile replacement	extension	dredging old channel
No. of sample properties with field underdrainage prior to project	6	1	7
No. of sample properties with field underdrainage installation since project	4	1	3
No. of acres with new field underdrainage	12	15	4
Total cost of new field underdrainage	$1315	$2000	$900
Farmer's estimate of no. of acres affected by drain	58	31	239
No. of acres assessed benefit	77	22	344
Land-use change	no change	no change	no change
No. of farmers reporting increased yields	5	1	1
Market value of increased crop production	$504	$275	$3689
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	$87	$133	$158
Types of input changes besides field underdrainage	none	none	bridge, dam
Average no. of days earlier seeding possible	2	3	2
Changes in livestock	none	none	none
Changes in gross income from livestock	o	0	0
Increase in income due to change in feed sales or purchases	0	0	0
Net annual increase in farm income (calculated)	$447	$192	$3671
Farmer's estimate of increase in income (mode)	0%	0%	0%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	never	never	(never) (6-10 yrs
Total cost of drain for sample properties	$4000	$4290	$2590

TABLE 5.5 (Cont'd) Pg.86

MERSEA TOWNSHIP (con'd.)	W. Marsh Drain	Strauss Land Co. Drain
Soil conditions	clay (brookston)	clay (Brookston)
Total no. of property owners	159 (70 agr.)	3
No. of owners interviewed	7	3
Type of drain project	dredging old channel	dredging old channel
No. of sample properties with field underdrainage prior to project	7	3
No. of sample properties with field underdrainage installation since project	0	1
No. of acres with new field underdrainage	0	42
Total cost of new field underdrainage	0	$3500
Farmer's estimate of no. of acres affected by drain	152	248
No. of acres assessed benefit	644	335
Land-use change	none	none
No. of farmers reporting increased yields	1	3
Market value of increased crop production	0	$2323
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	$33	$233
Types of input changes besides field underdrainage	foot bridge	none
Average no. of days earlier seeding possible	2	13
Changes in livestock	none	none
Changes in gross income from livestock	0	0
Increase in income due to change in feed sales or purchases	0	+$1920
Net annual increase in farm income (calculated)	0	2090
Farmer's estimate of increase in income (mode)	0%	1 - 5%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	Never	2 - 5 yrs.
Total cost of drain for sample properties	$1542	$2368

RAMSAY TOWNSHIP	TABLE 5.6 Pg. 87 Almonte Drain	Currie Drain	Duncan Drain
Soil conditions	loam and silt loams	silt loams and loams	silt loams
Total no. of property owners	22 (17 urban)	14	12
No. of owners interviewed	7	8	8
Type of drain project	dredging old channel	dredging old channel	dredging old channel
No. of sample properties with field underdrainage prior to project	0	2	1
No. of sample properties with field underdrainage installation since project	0	2	5
No. of acres with new field underdrainage	0	40	270
Total cost of new field underdrainage	0	$6000	$22,800
Farmer's estimate of no. of acres affected by drain	3	415	595
No. of acres assessed benefit	32	1188	523
Land-use change	none	some switch from non-pasture to grain-corn	some increase in corn
No. of farmers reporting increased yields	1	1	6
Market value of increased crop production	$24	$4337	$5695
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	0	$399	$6685
Types of input changes besides field underdrainage	none	none	more dairy and bee[f] cattle + fertilize[r]
Average no. of days earlier seeding possible	1	6	10
Changes in livestock	none	none	more beef and dairy cattle
Changes in gross income from livestock	0	0	+ $13,725
Increase in income due to change in feed sales or purchases	+$15	+$3200	+$1203
Net annual increase in farm income (calculated)	$24	$3938	$7250
Farmer's estimate of increase in income (mode)	0%	0%	1 - 5%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	never	never	(2-5) (6-10) yrs.
Total cost of drain for sample properties	$850	$3420	$9426

RAMSAY TOWNSHIP (con'd)	TABLE 5.6 (Cont'd) Pg. 88 Foster Drain	Munro Drain
Soil conditions	silt and clay loams	mainly sand and silt loams
Total no. of property owners	11	33
No. of owners interviewed	8	8
Type of drain project	new drain	dredging old channel
No. of sample properties with field underdrainage prior to project	0	0
No. of sample properties with field underdrainage installation since project	0	2
No. of acres with new field underdrainage	0	101
Total cost of new field underdrainage	0	$17,597
Farmer's estimate of no. of acres affected by drain	135	612
No. of acres assessed benefit	221	975
Land-use change	none	some switch from hay-grain to grain-corn
No. of farmers reporting increased yields	1	7
Market value of increased crop production	$335	$4157
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	0	$14,720
Types of input changes besides field underdrainage	none	more fertilizer and beef and milk cows
Average no. of days earlier seeding possible	1	13
Changes in livestock	none	more dairy and beef cattle
Changes in gross income from livestock	0	+$15,500
Increase in income due to change in feed sales or purchases	0	+$1305
Net annual increase in farm income (calculated)	$335	$3527
Farmer's estimate of increase in income (mode)	0%	1 - 5%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	never	6 - 10 yrs.
Total cost of drain for sample properties	$16,261	$33,115

WEST LUTHER TOWNSHIP	TABLE 5.7 Pg. 89 DRAINS NO. 1 + 4	DRAIN NO. 50	DRAIN NO. 52
Soil conditions	silt - loam (Perth + Brookston)	silt - loam (Harriston)	silt - loam (Perth + Brookston)
Total no. of property owners	20	7	4
No. of owners interviewed	12	6	2
Type of drain project	dredging old channel	dredging old channel	new drain
No. of sample properties with field underdrainage prior to project	3	0	1
No. of sample properties with field underdrainage installation since project	1	0	2
No. of acres with new field underdrainage	34	0	22
Total cost of new field underdrainage	$4500	0	$2800
Farmer's estimate of no. of acres affected by drain	342	124	35
No. of acres assessed benefit	2198	290	63
Land-use change	some swamp to grain, grain to corn	none	some switch from grain-hay to corn
No. of farmers reporting increased yields	5	1	2
Market value of increased crop production	$3153	$45	$1429
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	$2411	0	$486
Types of input changes besides field underdrainage	purchase beef cattle, pigs	none	more dairy cattle
Average no. of days earlier seeding possible	10		10
Changes in livestock	some increase in beef cattle and hogs	none	more dairy cattle
Changes in gross income from livestock	+$2950	0	+$951
Increase in income due to change in feed sales or purchases	0	0	+$544
Net annual increase in farm income (calculated)	$2842	$45	$1243
Farmer's estimate of increase in income (mode)	none	none	(1%) (1 - 5%)
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	6 - 10 yrs.	never	2 - 5 yrs.
Total cost of drain for sample properties	$9336	$6095	$2565

TABLE 5.7 (Cont'd) Pg. 90

WEST LUTHER TOWNSHIP (con'd.)	DRAIN NO. 53	DRAIN NO. 56
Soil conditions	silt-loam (Listowel) + muck	silt-loam (Listowel)
Total no. of property owners	5	10
No. of owners interviewed	4	7
Type of drain project	new drain	new drain
No. of sample properties with field underdrainage prior to project	1	0
No. of sample properties with field underdrainage installation since project	0	0
No. of acres with new field underdrainage	0	0
Total cost of new field underdrainage	0	0
Farmer's estimate of no. of acres affected by drain	60	134
No. of acres assessed benefit	169	500
Land-use change	none	none
No. of farmers reporting increased yields	1	2
Market value of increased crop production	$216	$345
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	0	0
Types of input changes besides field underdrainage	none	none
Average no. of days earlier seeding possible	3	3
Changes in livestock	none	none
Changes in gross income from livestock	0	0
Increase in income due to change in feed sales or purchases	+$100	+$333
Net annual increase in farm income (calculated)	$216	$345
Farmer's estimate of increase in income (mode)	none	none
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	never	2 - 5 yrs.
Total cost of drain for sample properties	$4605	$18,642

Table 5.8

BENEFIT-COST RATIOS FOR SAMPLE DRAINS

		5-yr. life of drain			12-yr. life of drain			20-yr. life of drain		
		Calculated at:								
BROOKE TWP. SAM		6%	8%	10%	6%	8%	10%	6%	8%	10%
Black	(1968)*	.51	.48	.45	1.01	.90	.82	1.38	1.18	1.02
Gov't. No. 1	(1967)	.59	.56	.53	1.17	1.05	.95	1.60	1.37	1.19
4623.13 Munro 9/10/68	(1965)	1.58	1.50	1.42	3.14	2.82	2.55	4.30	3.68	3.19
4459.33 Parker-Lucas	(1969)	.80	.76	.72	1.59	1.43	1.30	2.18	1.87	1.62
Stephens-Zavitz	(1967)	1.55	1.47	1.40	3.09	2.78	2.51	4.23	3.62	3.14
Tait	(1968)	1.77	1.68	1.60	3.53	3.17	2.87	4.83	4.13	3.58
Township Avg.		1.19	1.13	1.07	2.37	2.13	1.92	3.24	2.77	2.40
CALDWELL TWP. N. ONT. NO AIR.W.A										
Arbour	(1969)	.18	.17	.16	.36	.32	.29	.49	.42	.37
Clement	(1969)	.85	.81	.77	1.70	1.52	1.38	2.32	1.99	1.72
LaFerriere	(1970)	.69	.65	.62	1.37	1.23	1.11	2.41	1.61	1.39
Rainville	(1970)	.18	.17	.17	.37	.33	.30	.50	.43	.37
Savage	(1969)	1.74	1.64	1.56	3.45	3.10	2.81	4.72	4.04	3.51
Township Avg.		.53	.50	.47	1.05	.94	.85	1.44	1.23	1.07
CUMBERLAND TWP.										
788.32 Chartrand	(1964)	1.47	1.39	1.32	2.92	2.63	2.38	4.00	3.42	2.97
LaLonde-Cleroux	(1965)	0	0	0	0	0	0	0	0	0
1860.06 Robert Walsh	(1969)	.54	.51	.49	1.08	.97	.88	1.48	1.26	1.10
4385.73 Smith-Staal	(1969)	0	0	0	0	0	0	0	0	0
1065.26 Van Vliet	(1968)	.14	.13	.13	.28	.25	.23	.38	.33	.28
Township Avg.		.27	.26	.25	.54	.49	.44	.74	.64	.55
ELLICE TWP.										
Kuhryville	(1968)	.52	.49	.47	1.03	.93	.84	1.41	1.21	1.05
Ohm	(1967)	2.33	2.21	2.10	4.64	4.17	3.78	6.35	5.44	4.72
Quererquesser	(1968)	4.92	4.67	4.43	9.80	8.81	7.96	13.40	11.47	9.95
721.67 Satchell	(1969)	11.18	10.60	10.06	22.26	20.00	18.09	30.45	26.06	22.60
287.73 Siep	(1969)	2.83	2.68	2.54	5.63	5.06	4.57	7.70	6.59	5.72
Whaling	(1965)	2.36	2.23	2.12	4.69	4.21	3.81	6.41	5.49	4.76
Township Avg.		3.00	2.84	2.70	5.97	5.37	4.85	8.17	6.99	6.06

H.J. SMITH 271-3466

* Date of engineer's report

Table 5.8 (Cont'd.)

BENEFIT-COST RATIOS FOR SAMPLE DRAINS (Cont'd.)

	5-yr. life of drain			12-yr. life of drain			20-yr. life of drain		
	Calculated at: 6%	8%	10%	6%	8%	10%	6%	8%	10%
MERSEA TWP. MR. P. STOCK - TO CALL BACK									
1/3 NO — R. Anderson 1653.23 (1969)	.47	.45	.42	.94	.84	.76	1.28	1.10	.95
ARDA Coulson (1968)	.19	.18	.17	.38	.34	.30	.51	.44	.38
3820.52 W. James 10/10/67 (1965)	5.97	5.66	5.37	11.88	10.68	9.66	16.26	13.92	12.07
W. Marsh (1968)	0	0	0	0	0	0	0	0	0
1/3 — Strauss Land Co. (1969) 789.18 ARDA	3.42	3.24	3.07	6.80	6.11	5.52	9.30	7.96	6.90
Township Avg.	1.82	1.73	1.64	3.63	3.26	2.95	4.96	4.25	3.68
RAMSAY TWP. MR. DRYDGES									
BOTH RECEIVED ARDA Almonte (1966)	.12	.11	.11	.24	.21	.19	.32	.28	.24
Currie (1966)	4.85	4.60	4.37	9.67	8.68	7.85	13.21	11.30	.98
Duncan (1969)	3.24	3.07	2.92	6.45	5.80	5.24	8.82	7.55	6.55
Foster (1969)	.08	.08	.08	.17	.16	.14	.24	.20	.18
Munro (1967)	.45	.43	.40	.89	.80	.73	1.22	1.05	.91
Township Avg.	1.01	.95	.91	2.00	1.80	1.63	2.74	2.35	2.03
MR. DUNCAN WEST LUTHER TWP.									
Drain No. 52 (1968)	2.35	2.22	2.11	4.67	4.20	3.80	6.39	5.47	4.74
Drain No. 50 (1968)	.03	.03	.03	.06	.06	.05	.08	.07	.06
Drains No. 1 & 4 (1968)	1.28	1.22	1.15	2.55	2.29	2.07	3.49	2.99	2.59
Drain No. 53 (1968)	.20	.19	.18	.39	.35	.32	.54	.46	.40
10,140.97 Drain No. 56 (1969)	.08	.07	.07	.16	.14	.13	.21	.18	.16
Township Avg.	.48	.45	.43	.95	.86	.78	1.30	1.12	.97

study areas. Most property owners interviewed (195 out of 232) felt that drainage was beneficial, and the production data and benefit-cost ratios tend to confirm this general feeling. One hundred and seven of those interviewed felt that oulet drainage installations had led to increases in crop yield, and 179 indicated their willingness to pay for drain maintenance whenever it is required. One hundred and twenty-two also indicated that they would have supported the latest project without the government subsidy.

Beyond the general positive evidence concerning the impacts of drainage, considerable inter-township and inter-drain variation is revealed. The highest benefit-cost ratios occur in the traditional locations of high agricultural productivity (e.g., 12-year lifetime b-c ratios at 8% are Brooke--2.13, Ellice--5.37, and Mersey--3.26). So Southwestern Ontario would appear to benefit significantly greater than other parts of the province. Drains in some of the "frontier" drainage areas, in fact, barely pay for themselves, if they pay at all. Benefit-cost ratios comparative to those above are Caldwell--.94, Cumberland--.49, Ramsay--1.80, and West Luther--.86. It is inappropriate, however, to assume that all drains in one region are beneficial and all those in another are not, because very significant variation among drains in individual townships is evident.

The sample drains in Brooke tend to have modest but consistent b-c ratios that leave little doubt that drains "pay" in the area. Clearly, the expenditures have been worthwhile. The one drain with rather low b-c ratios (.90 for 12 years, 8%) was built primarily to alleviate drainage problems on roads, and was paid for locally by the municipality rather than individual farmers. Measuring benefits in areas like Brooke where drainage history goes back a long way and where most recent work is of a maintenance type is difficult because improvements may not only yield higher production but may

also prevent future declines should existing drains become defective. Theoretically, drain maintenance could be worthwhile even if the drain was not currently defective and if no increases in production followed. In this case the b-c ratio, as calculated in this study, would be 0.0! But the real benefit would be the prevention of future production declines when the drain did become defective. In actuality, however, it appears that maintenance is postponed until production problems are evident, which yields b-c ratios well in excess of 1.0. A recurring problem throughout the study was to determine whether drains were being constructed for the first time or whether modifications were being made on old ones. Often neither local farmers, the researchers, nor local officials could make the determination. The gently meandering watercourses being deepened could be "natural" or they could be remnants from old drains. Unfortunately, public records were of little use due to changes in drain names over time.

Caldwell, one of the twonships in northern Ontario with much recent drain construction, contains drains with great variation in b-c ratios. Two of the drains have led to very small increases in income, and to b-c ratios so low that the costs of construction will not be recovered. Two other drains have b-c ratios of about 1.5 (12-year lifetime), and the ratios of another are much higher.

Benefit-cost ratios in Cumberland (Eastern Ontario) are generally low, with only two drains likely to pay for themselves. Farms along two other drains have experienced no benefits at all. In nearby Ramsay, two drains with very high b-c ratios are evident, even though two others will not come close to paying off unless current responses change radically.

Ellice contains, on the whole, drains with the highest b-c ratios of any studied. Conversion of acreages from hay and small grains to corn and

soybean production seem to have helped produce the highly beneficial perspective. Like Ellice, Mersey has a high average b-c ratio, although here at least two drains will not pay for themselves.

Benefit-cost ratios in West Luther vary considerably, ranging from three drains with little beneficial response to two others where drainage construction has obviously been a wise economic investment.

5.4 Conclusions

It must be emphasized again that the data used in this analysis are, in most cases, estimates of questionable accuracy. Similarly, the calculations are based on very specific and limiting assumptions which must be fully appreciated prior to interpretation. Nevertheless, the researchers feel that the data and the derivations are valuable, and that, when used with caution, they can reflect a good assessment of benefits and costs.

On the whole, the general response in agricultural production justifies the construction of outlet drainage in the sample areas. A considerable variation in this trend is evident, however, between townships and between drains. Many of the sample drains, particularly in Eastern and Northern Ontario, have benefit-cost ratios below 1.0; and many of these have been beneficial to property owners only because of government grants (this conclusion is similar to that expressed in TOPECON Group Ltd., 1971). Even among the properties along a single drain a great variation in agricultural response is noted. It is quite normal for a drain to have a good benefit-cost ratio because of very high responses on a small minority of farms and no increases in production on the majority of properties.

It is felt that seven major factors account for the variation among drains in benefit-cost ratios:

(1) Productivity of the environment

The agricultural productivity of the environment varies considerably across Ontario due primarily to variations in soil and climatic conditions. Southwestern Ontario has a unique combination of good soils and a long growing season to give it a superior environment over the rest of the province. Since drainage construction costs are similar across the province, funds invested in drainage in Southwestern Ontario are bound to yield greater marginal agricultural productivity than in other regions. Similarly, investments in Eastern and Northern Ontario, with limited soil and climatic conditions, would be expected to yield lower marginal returns. This basic relationship, which tends to accentuate the comparative advantage of "privaledged" regions as capital investments are made, undoubtedly accounts for the general tendency of Southwestern Ontario to have higher b-c ratios than other parts of the Province.

On a more local scale, investment in drainage can lead to spectacular benefits if the investment permits switches to more lucrative land uses in addition to improving yields of existing ones. Such investments lead to "critical" changes in the productive environment which can be accompanied by very high b-c ratios. In the sample drains the highest b-c ratios tended to occur in areas where drainage permitted land to switch from hay or small grains to corn or soybeans. Ellice particularly contained a number of sample properties where drainage permitted this criticial switch--a switch which tended to occur further southwest several years ago.

(2) Installation of field underdrainage

The 1972 report by TOPECON Group Ltd. concerning agricultural land drainage in Eastern Ontario pointed out that when new outlet drains are installed beneficial responses from farmers only occur on a large scale if

field underdrainage is installed and attached to the outlet. This conclusion is reconfirmed by this study. Drains with high b-c ratios tend to be those where field underdrainage existed prior to the outlet project or where new underdrainage installation followed the project. Where field drainage was not installed, particularly in Eastern and Northern Ontario and in West Luther, unfavourable b-c ratios resulted.

(3) Special hydrological conditions

Outlet drains are often of some benefit to farms even without field underdrainage, but this is largely dependent on local hydrology. In most cases the benefits are very few, but under unusual circumstances outlet drainage alone can lead to b-c drainage ratios in excess of 1.0. Such is the case of the Savage drain in Caldwell, where the new drain prevents the flooding of fields with runoff from surrounding higher ground.

(4) Local initiative

Obviously an important determinant of the success of a drain is the initiative taken by local farmers to utilize its potential benefits. Such initiative, for example, might take the form of installing field underdrainage. The researchers discovered a great range in the degree of local initiative, and feel that it is an important reason for the variation in b-c ratios. The most successful drains tended to be those of fairly modest cost ($2,000-$4,000) with a fairly small number of farmers who had a genuine interest in the project. A common occurrence on the larger projects was for two or three farmers to experience all of the benefits, leaving the vast majority of landowners undergoing no changes. This accounts for the fact that many of the farmers on large drains reported little benefit (see the modal values in tables 5.1-5.7) even though the overall b-c ratios were well in excess of zero.

(5) Type of project

As indicated in secton 5.3, the type of drainage project has an important influence on the b-c ratios. This is particularly true for maintenance projects, where the most important benefits may be the unmeasured ones--i.e., the prevention of future production decreases.

(6) Quality of engineering

The engineer who designs a drain can have a profound effect on the b-c ratios. For example, the researchers observed some drains which appeared to be much too elaborate and costly for their intended purpose, which would lower the b-c ratios.

(7) Weather conditions since project

It was pointed out a number of times in the field that the ultimate effects of some drains could not be measured yet since the years following construction had had abnormal weather conditions. In Eastern Ontario particularly it was indicated that heavy rainfall has not permitted the full beneficial effects of new drains to be felt.

In conclusion it is important to note that the first six of these seven factors which affect b-c ratios can be evaluated, estimated, or controlled before any drain has to be constructed. It should be possible, therefore, to produce fairly good estimates of the benefits to be expected from drain construction, perhaps before the completion of an engineer's report, or certainly with expanded versions of those reports.

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Chapter 6

THE ENVIRONMENTAL IMPACTS OF AGRICULTURAL LAND DRAINAGE

6.1 Introduction

The organization of this chapter, which considers the influence of agricultural land drainage on the environment, differs considerably from the preceding chapter on agricultural benefits. The effects of change on the agricultural sector are well known and extensively documented. In contrast, research on the environmental impacts of drainage is fragmentary, and scattered in the literature of a number of disciplines. Consequently, the researchers have undertaken an extensive review of the literature in order to produce a comprehensive analysis of this topic. The effects of land drainage on the various facets of the environment, depicted in the model of local-scale impacts (Fig. 3.2), are considered in the initial sections of this chapter, using Ontario examples wherever possible. In the final sections of the chapter an assessment is made of the present situation in Ontario with respect to the environmental consequences of land drainage.

The practice of land drainage is probably as old as the art of agriculture. The first recorded examples occurred during the times of the Roman Empire and probably earlier. Since the 1850s very large acreages of land in both the United States and Canada have been drained for agriculture. Throughout most of this time period land drainage has been viewed solely in terms of its beneficial effects on agriculture. Inevitably however, the manipulation of the landscape through drainage practices also produces manifold effects on many other facets of the

environment which lie outside the agricultural sector, and as is often the case when man modifies his surroundings, not all of these repercussions are beneficial.

Little emphasis has been given until recently to the possible broader environmental impacts of agricultural land drainage. Basic texts on drainage engineering contain little or no reference to such issues (Ayres, 1939; Luthin, 1957; Pickels, 1941). Bibliographies on land drainage usually contain no references to non-agricultural impacts, or if they do, the paucity of references listed indicates the lack of attention which has been accorded to these problems. (Crook, 1968; De Vries, 1966).

In the last decade there has been an explosion of interest in man's relationship with his environment. In this period greater attention has focused on some of the environmental effectsof land drainage, particularly in relation to game animals and sport fisheries. Nevertheless, an analysis of the existing literature exposes a lack of detailed scientific data on many of the potential effects of drainage.

The ultimate objective of drainage operations is to increase crop yields, to improve crop quality, or to improve the condition of the soil so that higher value crops can be grown. (Wesseling et al. 1957). Agricultural land drainage achieves these aims by producing a number of major alterations in soil properties.

Land drainage facilitates the removal of gravitational water from the soil (Pickels, 1941). Gravitational or free water forms that fraction of soil water which is in excess of the soil moisture-holding capacity. Normally this water drains downwards due to the force of gravity. However, in areas of high water table gravitational water remains on or just

below the ground surface. Drainage lowers the water table and removes this excess water. Capillary water which forms a film around each soil particle is retained against the pull of gravity and cannot be drained off. It is capillary water which is used by crops.

The removal of gravitational water actually results in an increase in the amount of available capillary moisture in the soil. The removal of excess water results in an improvement of soil structure because of increases in the activities of microorganisms, greater plant root development and the action of the mechanical processes of shrinking and swelling which occur due to changes in soil moisture content (Edminster and Reeve, 1957). The improved soil structure enables the soil to hold greater amounts of capillary water. Furthermore, the lowering of the water table encourages plant roots to penetrate deeper into the soil thus providing access to a greater amount of capillary moisture. The increase in rooting depth also enables plants to utilize nutrients from a greater volume of soil.

The temperature of soils plays an important role in seed germination and root growth. Well drained soils warm up faster than saturated soils because in the latter solar radiation is used largely to evaporate water rather than raising soil temperature. Drainage by removing excess water enables the soil to warm up more quickly.

Poor soil aeration is a primary factor in poor crop production on wet soils. The excess gravitational water in these soils fills the pore spaces, thus excluding air. Plant roots and microorganism populations in the soil require oxygen. Lowering the water table by means of drainage enables air to occupy the pore spaces in the soil body.

The effects produced by drainage on soil properties are obviously beneficial to agricultural crops. However, areas of excess water in the landscape provide the habitat for many species of plants and animals. These areas also play a significant role in the hydrological cycle. The act of drainage may therefore be damaging to these non-agricultural aspects of the environment.

6.2 Natural Vegetation

The construction of drains and the channelization* of existing streams in order to increase the flow of water from the land surface results in the destruction of vegetation along the path of the excavation. Clearance of vegetation extends for a variable distance, often 30 to 40 feet at right angles to the drain, because of the passage of dredging machinery and the dumping and spreading of the excavated spoil. The swathe of clearance along the drain or channelized stream can be particularly damaging in woodland where the removal of valuable timber may be involved. Drainage can result in even greater destruction of natural vegetation in situations where permanent wetlands are converted to agricultural use. For example, at the present time approximately 400 acres of forest consisting of white cedar, trembling aspen, birch, and balsam fir is being sold on the Stroud swamp in Simcoe County for market gardening purposes. (see p. 184).

Land drainage also affects natural vegetation by altering surface

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*Channelization usually involves the straightening and deepening of a natural stream.

and soil water levels. In many cases drains are installed in permanent wetlands in order to facilitate the drainage of adjacent agricultural land or to allow the drain to be continued to a point where adequate outlet is provided. In these circumstances the existing vegetation which remains uncleared may be modified considerably. The installation of a drain will remove areas of surface water resulting in the elimination of submergent and emergent aquatic plants. These areas will subsequently become sites for colonization by terrestrial vegetation. In bog areas drainage may lower the water table, affecting the growth of various plants adapted to this specific type of environment. For example, a ditch dug in 1938 is changing the vegetation composition of the eastern section of the Mer Bleue near Ottawa. The alteration in water level is permitting the invasion of a variety of plants, including trembling aspen and balsam poplar, which are usually excluded from this type of bog (Joyal, 1970).

A substantial amount of research has been conducted by forestry scientists on the effects of drainage on hardwood swamps and forested bogs.* This research suggests that drainage can have beneficial effects on wetland forests by increasing growth rates of a variety of tree species. More than two million acres of forest land throughout the Gulf and the Atlantic coastal plains of the southeast United States have been ditched in order to improve tree growth and restock marginal lands (Klawitter, 1965, 1970). In Scandinavia partial drainage has been practised for many years and has greatly improved forest growth on bog areas (Lindberg, 1926; Lukhala, 1927).

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*Definition of the terms swamp and bog can be found on pages 168 and 169.

Research in northern Minnesota on the effects of drainage in areas of black spruce, tamarack and cedar has revealed average increases of 100% in growth rates on drained areas in comparison with undrained sites (Averell and McGrew, 1929).

There is some feeling among Ministry of Natural Resource foresters in Ontario that land drainage for agricultural purposes may have a detrimental effect on woodlands. Nevertheless adverse effects of drainage on forested areas are not well documented in comparison with the literature on beneficial effects. Klawitter (1970) notes that swamp vegetation is well adapted to a wet environment and that drainage of ponds and swamps may be detrimental to these species, and may even kill older trees if it permanently lowers the water table.

It should be stressed that in the swamps of Southeastern United States the ditches are designed specifically for forestry purposes and are frequently only two feet in depth. They are aimed at water regulation rather than uncontrolled drainage. Agricultural drains, on the other hand, are often five or six feet deep and are not designed for forestry purposes. Consequently, the decline in water table may be rapid and severe enough to produce a number of detrimental consequences. Wilde et al. (1950) notes that the removal of beaver dams and the consequent abrupt alteration of ground water level causes considerable damage because of drought injury. Affected 30-year-old stands of trembling aspen experienced major reductions in growth rate in the two years after removal of beaver dams.

The drainage of forested bogs can also increase fire hazards because of the drying out of the peat adjacent to the drain and the thick growth of inflammable annual plants along the right of way. In Minnesota many forest

fires in drained areas have burnt along the ditches (Averell and McGrew, 1929).

Where ditches are cut through woodland the cleared zone may increase local wind velocity because of the funnelling effect of the narrow cleared strip. Measurements of wind velocities in clearcut and uncut forest land near Hinton, Alberta indicated velocities less than one mile per hour in timber compared with 29 miles per hour in clear cuts (Pengelly, 1972). The increased velocity in the cleared strip along the drain may result in some wind throw damage to trees near the margins of the strip. In some circumstances, however, it is possible that ditches through hardwood swamps, if they lower the water table slightly, may reduce wind throw since the trees are encouraged to extend their roots deeper into the soil, thus providing a firmer anchorage.*

Drainage may be very detrimental if it involves upland hardwood stands dominated by sugar maple and beech. Abrupt lowering of the water table in these areas may reduce growth rates since the species are less adaptable than the swamp hardwoods to major fluctuations in the water table. Moreover, disposal of sediment dredged from the drain may injure maples along the edges of the cleared tract. Spreading of spoil may raise the soil level around these trees by six inches or more. Sugar maple can be killed by such alterations in ground level, which in turn affect soil aeration and compaction (G. Murchison pers. comm.).

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*Personal communication from G. Murchison, Ministry of Natural Resources, Hespeler District.

6.3 Wildlife

Agricultural land drainage may have a variety of effects on wildlife. The most important impacts occur in situations where permanent wetlands of various types are drained. Wetlands constitute key components of the landscape for many types of wildlife providing cover, food resources and breeding sites. Drainage activities may have a considerable influence on wildlife, even in areas where permanent wetlands are not affected. In areas of intensive agriculture open drains which have not received recent maintenance contribute significantly to the total area of semi-natural vegetation. The reconstruction of these drains will destroy, at least temporarily, the usefulness of the habitat for wildlife.

(a) Waterfowl

The major portion of research on the effects of drainage on wildlife has been devoted to waterfowl and a variety of game animals because of their significance for recreation. The effects of drainage involving permanent wetlands probably has a greater detrimental effect on waterfowl than on most other types of wildlife. If the object of drainage is to convert the wetland to agricultural use the habitat is lost not only for waterfowl but also for all other types of wildlife which utilize the area. However, in areas where wetlands are drained but are not cleared for agriculture the habitat may still be utilized by various types of wildlife, but the removal of surface water eliminates the value of the area for waterfowl and other organisms which require an aquatic environment.

The extent to which land drainage has an adverse effect on waterfowl depends to a considerable degree on the type of wetland involved. Areas of temporary standing water which occur in small depressions or on areas of

flat terrain in the agricultural landscape are often drained by tile systems which outlet to the municipal drains. These "wet spots" are of little significance to waterfowl because they frequently dry up in late spring and they usually do not support aquatic vegetation.

Other types of wetlands which are relatively insignificant for waterfowl include swamp areas covered with dense stands of white cedar, a common type of wetland in Ontario; and various types of bog which have few areas of surface water (Benson and Bellrose, 1964). However, the drainage of a bog may have indirect effects on waterfowl if the bog acts as a water source for other types of wetland in the vicinity.

The drainage of small marshes* eliminates a key habitat for waterfowl. Small marshes containing a few acres of shallow open water and surrounded by a fringe of various types of emergent aquatic plants are ideal habitats for ducks. These small marshes are frequently found in the numerous depressions of glacial moraine areas. Good examples can be found on the Oak Ridge moraine which extends in an east-west direction from Rice Lake to the Niagara Escarpment, and on patches of moraine around Woodstock and Guelph. Duck species breeding in the small marshes of Ontario in order of importance are mallard, blue-winged teal and black duck. Some indication of the production of these areas can be gained from a brood production survey conducted by the Canadian Wildlife Service in 1970 from 11 small marshes in King Township, north of Toronto. Fifty-three broods were recorded on the 180

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*A definition of the term marsh can be found on page 168.

acres of marshes, giving an average production of one brood per two acres.*
The countless beaver ponds in the province also provide a habitat for waterfowl which is somewhat similar to the small marshes, though in most cases production is lower.

Hardwood swamps constitute another important wetland type for water fowl. These swamps consisting of tree species such as silver and red maple, black ash, willow, and cottonwood contain shallow standing water, and they may only dry out in late summer one year out of two. These swamps form important breeding areas for mallard, wood duck and black duck and have average productions of approximately one brood per five to ten acres (D. Dennis, pers. comm.). The construction of drains in these areas removes the surface water and completely eliminates the value of the habitat for waterfowl.

The final type of wetland of importance to waterfowl in Ontario is the large permanent marsh. Such marshes are found along the shores of the Great Lakes, for example the marshes of Lake St. Clair. Large inland marshes such as Luther Marsh and Shirley's Bay Marsh on the Ottawa River can also be included in this category. These marshes have relatively low breeding densities; for example, the average production for Lake St. Clair marshes is one brood per 60 acres (Canadian Wildlife Service, in preparation). Nevertheless, because of their large size these marshes constitute significant production areas. Moreover, the large inland and Great Lakes marshes are tremendously significant as staging areas for the migration of waterfowl in spring and autumn.

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*Personal communication from D. Dennis, Canadian Wildlife Service, Aurora, Ontario.

A survey of marshes along the Ontario shoreline of Lakes St. Clair, Erie and Ontario indicates that a possible maximum of approximately 2,500,000 ducks and geese use these marshes during autumn migration (Bellrose, 1968). Similarly a waterfowl census on October 3, 1957 gave estimates of 15,000 ducks on Luther Marsh (Boyer and Devitt, 1961). The drainage of marshes of this type and their conversion to agricultural use will obviously have a major adverse effect on waterfowl.

The reconstruction of existing drains in areas where wetlands are not involved may also affect waterfowl. It is likely that the drains themselves are used for breeding, primarily by mallards, in some regions of Ontario. Counties which may be important in this respect are Middlesex, Elgin and the eastern portion of Lambton, where alternative wetlands are largely absent (D. Dennis, pers. comm.). Drains in Kent and Essex counties are probably not used by mallards because of the proximity of large marshes on Lake St. Clair and Lake Erie. Unfortunately, no data are availabe on the extent of breeding by ducks in drains. In many cases the raising of broods may be unsuccessful because the drain runs dry early in the summer, or becomes choked with plant growth eliminating areas of open water.

Although the effects of agricultural land drainage on waterfowl are almost always adverse, there are rare occasions when indirect and largely accidental benefits may occur. For example, in areas such as Eastern Ontario the installation of tile drainage may encourage the growing of corn instead of pasture, thus providing more feed in fall for migrant waterfowl. In some bogs the installation of open drainage ditches and subsequent damming of these drains by beaver, has produced

small lakes which have enhanced waterfowl breeding potentials of the bog.

(b) Other Types of Wildlife

A wide variety of other types of wildlife besides waterfowl are dependant on an aquatic environment. The drainage of wetlands results in the disappearance of the habitat of marsh birds such as herons, bitterns, coots, rails and red-winged blackbirds, as well as important furbearers such as muskrat, beaver, otter and mink.

Other types of wildlife which are not as directly dependant on aquatic environments may nevertheless suffer adverse consequences, if the wetlands are cleared and converted to agricultural use. Many game animals depend on wetlands primarily for cover and in some cases for food. Wooded swamps, particularly if they containclumps of cedar which provides excellent cover, interspersed with areas covered with scrub and sapling stages of preferred foods such as striped and red maples, aspen and sumac, provide good wintering areas for deer. (Thomasson, 1972) In Simcoe County, examination of wooded bogs indicates that deer use these areas for protective cover during the day and feed in the fields surrounding the bog at night (Leeson, 1969). Wetlands also provide cover, particularly in winter, for pheasants, grouse, Hungarian partridge, and European hare. The importance of wetlands as part of the total sustaining environment of wildlife is such that the use of a wetland for agriculture will produce a substantial reduction in wildlife over a considerable surrounding area.

Adverse effects on wildlife may occur even when drained wetlands are not cleared for agriculture. Deer, for example, utilize the early shoots of sedges and grasses in spring and aquatic plants in the summer (Cumming

and Walden, 1970). Ditches which are located in forested wetlands used as wintering areas by deer may cause the loss of animals by drowning. In the past three years, three deer and six moose have drowned in steep-sided drains which cross the Alfred Bog in Prescott County, Ontario.* The removal of areas of surface water in a drained wetland will substantially reduce the populations of frogs and other amphibians, as well as the rich insect life, thus diminishing food resources for many types of wildlife.

The drainage of wetlands is of major importance in terms of its adverse effects on wildlife. However, the potential damage to wildlife resulting from maintenance and reconstruction of existing drains must not be overlooked. The importance of drainage ditches as wildlife habitats probably varies considerably. In some areas such as Eastern Ontario where there is a large variety of alternative semi-natural habitats, the ditch may be unimportant. In contrast, older drains which have not been maintained recently may be very significant for wildlife in the intensively farmed areas of Southwestern Ontario, where alternative habitats such as woodlands and small wetlands are in short supply. The aquatic habitat of the drain may be utilized by muskrats, raccoons, and mink as well as some waterfowl. The bank vegetation of these drains may also provide cover for wildlife, particularly small game species such as pheasant and hare in winter and spring when fields provide no cover.** In these circumstances the reconstruction or maintenance of drains will adversely affect wildlife until the vegetation cover regenerates.

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*Personal Communication from G. Whitney, Ministry of Natural Resources, Kemptville District.

**Personal Communication from A. Hauser, Wildlife Branch Ministry of Natural Resources, Queen's Park Toronto.

6.4 Water Table

Agricultural drainage is normally accomplished through the installation of tile underdrainage for the removal of subsurface gravitational water and open ditches for the removal of surface water, and to provide an outlet for tile drainage networks. In all cases the effect of artificial drainage is to increase the efficiency with which available moisture is collected and conveyed to natural water courses. This removal of surface and gravitational water from the soil can be expected to result in impacts on the physcial hydrology of an area. In particular it is likely to result in impacts on the level of the water table and on the magnitude and timing of streamflow. The particular effects of an individual drainage project will be related to the local topographic and hydrogeologic patterns.

In evaluating the impacts of land drainage on the water table, it is necessary to consider the relationship between the area of excess moisture and the water table. Three situations may be identified, moisture may be perched above the ground water table, the moisture may be in an area of ground water recharge, or the moisture may be in an area of ground water discharge.

The first situation identified above is typical of localized areas of impermeable soils where excess moisture, the result of precipitation, accumulates at or near the ground surface. The impermeable layers separate this moisture from the water table. Such moisture is said to be perched above the water table and drainage activity in these areas will remove this excess moisture without any water table effects.

The second situation identified is that of an area of ground-water recharge. Excess moisture, the result of precipitation, accumulates at or

near the surface and is able to infiltrate into the soil and percolate downward to recharge ground water storage. Drainage activity in such an area will remove the excess moisture before it percolates to the water table and may result in the lowering of the water table. The amount of lowering will depend on the local hydrogeologic conditions and the size of the area to be drained. In general this type of ground-water recharge may be associated with areas of seasonal excess moisture. In the drier areas in the western plains prairie pot holes have been studied in detail; and their local role in recharging ground water storage has been identified (Eisenlohr and Sloan, 1968; Sloan, 1970).

The third situation identified with respect to areas of excess moisture relative to the water table is that of areas of ground-water discharge to the surface. This situation is often associated with permanent wetlands which act as source areas for streams in humid areas. In these situations the level of excess water on or in the soil corresponds to the water table. Under these conditions surface water bodies including streams are said to be effluent in that they are fed directly by ground-water flow. Drainage activities in areas of this type are likely to have direct effects on the water table. When existing watercourses are deepened there will be a temporary increase in the rate of ground-water discharge which will result in permanent lowering of the water table. When new watercourses are constructed the hydraulic gradient or the slope of the water table will be permanently changed and the water table will be lowered accordingly. This type of water table change related to drainage activity has been studied in Southern Michigan where water tables have been lowered by several feet by drainage activity (Zumberge, 1957). In the present project the researchers

found examples of irrigation ponds in the sandy soils of Norfolk County which had experienced lower water levels since drain construction on a nearby watercourse.

In addition to the relationships between areas of excess moisture and the water table, it is important to recognize the importance of soil properties. In particular the hydraulic conductivity or permeability of the soil must be considered. In highly permeable sandy soils a drainage work may collect water from a wide area. However, in relatively impermeable clay soils a drainage work can only collect water from the immediate area, or the surface. The need to space tile underdrainage more closely in areas of impermeable soils than in areas of permeable soils reflects this characteristic. A study in Minnesota detailed the effects of a drainage ditch on the water table in organic soils (Boelter, 1972). In a case where the water table was in the surface horizons of highly permeable fibric peat the effects of a new ditch on the water table were observed as far as fifty meters from the ditch. In a case where the water table was in the lower horizons of less permeable partially decomposed peat, water table changes were only observed within five meters of the ditch. The consideration of local conditions is most important in any assessment of water table changes relating to land drainage.

In situations where lowering of the water table results from land drainage, the implications may include reduced water levels or the drying up of surface wells and ponds, and a significant reduction in dry season streamflows.

6.5 Streams and Lakes

Agricultural land drainage produces a variety of changes in streams and lakes. In some cases permanent stream channels are straightened and dredged in order to accomodate increased flows from tile and open drains. This channelization may seriously affect sport fisheries and will also produce alterations in sediment loads and various other characteristics over considerable distances downstream. The maintenance and reconstruction of existing drains which are not permanent streams will probably result in less direct damage to fish populations, because of their absence in these areas, but once again alterations in sediment load and water temperature may produce impacts on fish populations at other locations in the drainage network. The installation of tile drains which outlet into municipal drains also produces alterations in streams and lakes by changing nutrient loads and hydrological characteristics.

The main impacts of land drainage on streams and lakes can be classified into the following categories:

(a) Stream flow

(b) Stream sediment load

(c) Stream channel form

(d) Water temperature

(e) Water chemistry

(f) Stream biology

(a) Stream Flow

Land drainage activity can be expected to affect both the magnitudes

and the timing of streamflow events as recorded in the stream hydrograph.* Drainage activity results in some increase in the total yield of streamflow from an area. The increased efficiency with which drainage works collect excess moisture and convey it to natural watercourses reduces the opportunity for evapotranspiration and results in increased streamflow. The actual amount of increase in streamflow will be related to local conditions such as the size of the area drained, the hydrogeologic characteristics of the area and the potential evapotranspiration rates.

Probably the most significant effect of drainage activity on the physical hydrology of an area is its impact on the timing of streamflow and this effects the magnitudes and durations of high and low flows. Excess moisture standing on the soil surface or retained as gravitational water in the soil is actually water held in temporary storage. This water normally enters storage during spring snowmelt or as the result of precipitation. In most cases water in temporary storage is not permanently impeded from contributing to streamflow but rather is slowed in its movement as compared to overland flow. Under natural conditions some of the excess moisture will evaporate, and some will move either as throughflow or as ground-water flow towards local watercourses. Where local watercourses are effluent, in that they receive ground-water flow directly, this flow provides baseflow, which is the gradual release of ground water over an extended period of time. This baseflow is extremely important in maintaining low streamflows during seasons when evapotranspiration losses are greater than precipitation inputs.

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*The stream hydrograph is a graph of stream discharge plotted against time.

Construction of drainage works result in the rapid collection of excess moisture and its conveyance to natural watercourses. Removal of this moisture from temporary storage and its addition to streamflows will result in increased flood peaks and in a reduction in the amount of baseflow available to maintain low flows. These effects will be observed both in the annual hydrographs and in the storm hydrographs of a stream which has undergone drainage activity. The annual hydrograph will be altered in that the spring peak flow is likely to be higher and its recession steeper with lower summer flow, while the individual storm hydrograph will also have higher peaks and steeper recessions. Drainage induced changes in stream hydrographs are of course closely related to the amount of land which is drained in proportion to the size of the watershed. Individual drainage projects involving only a few hundred acres are not likely to produce major changes in streamflow. The effects of multiple drainage projects however, are additive and many small drainage projects may add up to major changes in the stream hydrographs at downstream sites. Such changes may result in increased flood damage downstream and in reduced low flows. It should be recognized that such regime changes may work directly against extensive flood control and low flow augmentation programmes and structures which may already be in operation within the basin.

The special case of the role of wetlands in regulating streamflow requires consideration. As a result both of their flat surfaces and the nature of the soils involved, wetlands provide a large volume of water storage. In discussing the relationships of wetlands to streamflow, it is important to recognize the distinction between perched and ground-water wetlands (Verry, 1970, and Verry and Boelter, 1971). Perched wetlands

develop in basins perched above the water table and are normally the result of localized deposits of impermeable soil. The water stored in perched wetlands is derived from precipitation on the local drainage basin and the outlet is usually a small stream. Drainage of perched wetlands results in the loss of temporary storage and therefore will result in increased magnitudes of peak flow. However drainage of perched wetlands is unlikely to seriously affect the seasonal pattern of streamflows particularly low flows. Detailed study of perched wetlands in Northern Minnesota has revealed that while these areas are important regulators of storm flow, they are not important regulators of annual flow patterns (Verry, 1970). Perched wetlands are important regulators of spring runoff and storm flows because their temporary water storage function results in reduced peak flows and a gradual recession. The gradual recession may deplete the storage to such an extent that runoff will cease during dry periods of high evapotranspiration. Under dry conditions perched wetlands may actually act as water sinks as storm runoff is taken into storage and lost through evapotranspiration.*

The second type of wetland which has received detailed study in Northern Minnesota is the ground-water wetland. These wetlands act as discharge areas for ground-water and the water level in the wetland is simply an exposure of the water table. This type of wetland provides an important temporary storage for storm flow and spring runoff and also acts as an important source of ground-water baseflow and therefore

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*Personal communication from Professor H. Ayers, Faculty of Engineering, University of Guelph.

regulates both high and low flows in the outlet stream (Verry, 1970 and Verry and Boelter, 1971). The hydrology of wetlands of this type in Southern Ontario has been described by Prasad (1961) and by Rai (1962). Drainage of ground-water wetlands will result not only in the loss of temporary storage and increased peak flows but also in possible changes in the rates of ground-water discharge which may affect the timing of baseflow in the stream. Impacts in this case may include substantial reductions in low flows during dry seasons.

While the impacts on streamflow resulting from wetland drainage may not be overly significant in individual cases, it is again most important that the additive downstream effects of the drainage of several wetlands within a single drainage system be recognized.

(b) Stream sediment loads

The major portion of increased stream sediment loads is probably produced during dredging operations and in the immediate post-construction phase when erosion of unvegetated banks will be at a maximum. An examination of a sample of 12 drains of various ages in West Luther Township, Wellington County indicated that a time period of approximately five to seven years is necessary for vegetation to cover more than 75 per cent of the surface of the drain banks. The drain banks in this region consist primarily of clay loam and loam till which is prone to considerable slumping, and this may reduce the speed of plant colonization. On other types of bank material the rate of revegetation may be considerably different from that found in West Luther.

The sediment released during ditching and in the post-construction phase may have a lasting effect on aquatic environments downstream.

Unfortunately, there is a lack of quantitative data concerning the amounts of sediment contributed to streams by land drainage activities. Hansen (1971) states that turbidities averaging 31.2 per cent higher were measured in the channelized sections in comparison with natural sections of the Little Sioux River, Iowa during a period of low run-off.

Despite the absence of research on this topic, some inferences can be drawn from studies of natural streams which may indicate the extent of sediment contribution from land drainage operations. Research on natural streams suggests that bank erosion contributes a major portion of sediment load. Investigations in southwest Scotland reveal that 93 per cent of the total sediment removed from a mountain grassland drainage basin resulted from erosion of river bluffs (Kirkby, 1967). Approximately 55 per cent of the sediment load increase in a 26 mile section of the Pine River in the northwestern part of Michigan has been attributed to bank erosion (Hansen, 1971). Other studies suggest that bank erosion may contribute between 30 and 60 per cent of the sediment load even in drainage basins which contain considerable areas of cultivated land (Anderson, 1954; Striffler, 1964). In view of these studies of streams where a considerable proportion of the banks are covered with vegetation, it appears not unreasonable to suggest that the very extensive disturbed bare banks of drains and channelized streams in the post-construction phase, will contribute in a substantial manner to sediment loads.

(c) Stream Channel Morphology

Drainage activity may involve the channelization of natural streams and/or increases in the magnitudes of high flows. Changes of these types may be expected to result in changes in channel morphology. Stream

systems, over a period of time, tend to achieve through natural processes a graded or equilibrium state in which the stream gradient, the channel form, and other physical characteristics are adjusted so as to move the available sediment with the available discharge and a minimum expenditure of energy (Leopold, Wolman and Miller, 1963). Changes in any of the characteristics of a natural stream, such as are involved in channelization or increased flood flows, will result in upsetting the equilibrium, and adjustments are to be expected.

Channelization usually involves the straightening and deepening of a natural channel in order to facilitate more efficient flow. This practice results in shortening the length of the channel, increasing the gradient of the channel and increasing the velocity of flow. The increased flow velocity will produce an increase in available energy, and it is likely that erosion will take place as the stream attempts to regain equilibrium. The literature contains references to increased bank and gully erosion resulting from channelization projects (Emerson, 1971). Unfortunately, the projects studied are on a larger scale than those involved in drainage works in Ontario. If drainage activity results in increases in the magnitude of flood flows, it is likely that the extra energy involved in the movement of greater volumes of water will result in changes within the system. Increased flows may be associated with increased erosion as the stream adjusts to regain equilibrium. While it is beyond the scope of this report to attempt to detail the complex adjustments which will take place when the equilibrium of a stream system is upset, it is imperative that the likelihood of changes in channel morphology when disturbance takes place be recognized and taken into account.

(d) Water Temperature

The reconstruction of existing drains and the channelization of permanent streams involves the removal of bank, as well as aquatic vegetation. The consequent exposure of water to direct solar radiation often produces substantial increases in water temperatures. A comparison of water temperatures in channelized and unchannelized sections of the Little Sioux River in Iowa showed greater daily fluctuations during summer in the channelized sections (Hansen, 1971). Maximum and mean daily water temperatures averaged 0.3 degrees centigrade and 1.3 degrees centigrade greater respectively in the channelized section during July. In North Carolina the average summer water temperature of 28 sections of natural stream where the forest canopy had been undisturbed was 72 degrees farenheit compared to an average of 79.4 degrees farenheit on 46 channelized stream sites. (Tarplee et al. 1971). Two channelized streams in this study had summer water temperatures exceeding 90 degrees farenheit, the maximum legal water temperature permitted under the State of North Carolina's water quality standards.

The extent of temperature rise as a result of ditching will depend in part on the amount of shading by bank vegetation prior to removal. Other factors which will influence temperature changes include various hydrological characteristics of the drain such as discharge and water depth.

(e) Water Chemistry

Land drainage may effect stream water chemistry in a number of ways. The increased sediment load created by drain construction adds nutrients adsorbed on sediment particles to the aquatic system. However, the most important impact arises from the installation of tile drainage systems which accelerate the movement of water from fields into open drains and permanent

streams. Consequently, it is likely that fertilizers and pesticides which are added to fields may also be removed more rapidly into streams and lakes.

In the absence of tile drainage, water infiltrates slowly through the soil and moves towards the stream channel, either as through-flow in the soil body, or as base-flow from the ground water table. During this period a variety of chemical and biological actions take place between the soil and the water passing through it, which will probably decrease the amounts of various chemical elements reaching the stream system.

The removal of phosphorous and nitrogen from fields into drainage systems is of most concern because of their role in eutrophication. Increases in phosphorous release are not a major problem with respect to tile drains because this element, when applied in fertilizers, is converted to a water-insoluble form within a few hours (Taylor, 1967). On the other hand, nitrogen applied to the soil is rapidly transformed from the ammonia form to the nitrate nitrogen form. Nitrate nitrogen is easily soluble and moves downwards rapidly in the soil and can be removed by tile drains.

The contrast in behaviour of nitrogen and phosphorous is illustrated by a recent study of tile drain discharge from a grain field into Tecumseth Township, Simcoe County, Ontario (McCague, 1972). Nitrogen and phosphorous were measured in the discharge from the tile drain at weekly intervals from the end of April to the time the drain ceased to discharge in mid-July. Very low concentrations of phosphorous were found in the drain discharge, but nitrate nitrogen concentrations were often above 10 PPM and reached peaks of 80 PPM a week after fertilizer was added to the field.

A variety of other studies also indicate that accelerated losses of nitrogen through tile drainage systems may contribute to nitrate levels in streams and lakes. Investigation of nutrient losses from tile drainage systems in fields under irrigation indicated that nitrogen compounds were readily removed, while phosphorous appeared to be mainly fixed (Johnston et al. 1965). Plant nutrient losses measured in tile drainage discharge from cropping systems on the Brookston Clay in southwestern Ontario indicate relatively low releases of phosphorous, whereas nitrogen, calcium, magnesium and potassium were higher (Bolton et al. 1970). It was also noted that nutrient loss was influenced predominantly by the amount of water flowing through the soil and that large nutrient losses resulted in seasons when large amounts of drain flow occurred.

Less research has been carried out on the effects of tile drainage systems on the movement of pesticides. Johnston et al., (1967) observed that pesticides of low solubility such as DDT were only found in slight amounts in tile drains, whereas highly soluble materials such as lindane were removed readily from the field in tile drain discharge.

(f) Stream Biology

Alterations in stream hydrology, channel morphology, water chemistry, sediment loads, and water temperature caused by land drainage in turn produce changes in stream biology. All biological components of the aquatic system may be affected though most research has been devoted to sport fisheries.

The reconstruction of existing drains and the channelization of permanent streams has a number of detrimental effects on fish populations and on the flora and bottom fauna of streams. Many of these effects are direct consequences of the ditching activity. Channelization and drain

reconstruction produce flat uniform bottoms eliminating the alternating riffles and pools of natural streams. Extensive straightening of natural stream channels results in considerable reductions in the length of the stream which in turn will lower the standing crop of fish. Straightening of the Chariton River channel in Putnam and Adair Counties, Missouri resulted in the loss of 29.1 miles of stream, a reduction of 46.7 per cent in stream length (Congdon, 1971).

The greatest direct impact of ditching activity is the complete elimination of vegetation cover from the stream or drain. The presence of aquatic vegetation, large boulders, natural stream obstructions such as tree trunks and branches, overhanging bank vegetation and undercut banks provide essential escape cover for fish populations. The elimination of this cover by ditching produces a sterile environment which will not support substantial fish populations.

A number of studies have compared fish populations of channelized and unchannelized streams. Research on streams of North Carolina's coastal plain indicate that natural streams have an average carrying capacity per surface acre in excess of three times that found in channelized streams (Tarplee et al., 1971). In unchannelized sections of the Chariton River, Missouri 21 species of fish were found compared to 13 species in the channelized river. The standing crop of fish in the unchannelized river was estimated to be 1,654.1 pounds per mile (304.4 pounds per acre) compared to 431.1 pounds per mile (52.9 pounds per acre) in the channelized river, (Congdon, 1971).

The effects of drain reconstruction on trout populations has been assessed recently in Norfolk County, Ontario (Manson, 1972). A number of

physical parameters and the standing crop of brook trout were compared between a channelized and natural section of Massecar Creek. (Table 6.1) It should be noted that the downstream section which was chosen to represent natural conditions was probably adversely affected by siltation during ditching and therefore provides a conservative estimate of the potential fish population. Manson, (1972) also carried out an analysis of short sections of unditched stream immediately upstream from road culverts and compared them with ditched sections immediately downstream from the culverts of Hay Creek in Charlotteville Township and South Creek in Middleton Township, Norfolk County. (Table 6.2). The unditched sections are upstream from the ditched sections and therefore have not been damaged by sediment. In these examples dredging has resulted in a reduction of greater than 90 per cent in trout biomass.

Although in most cases the results of ditching are detrimental to stream biology there may be occasional circumstances in which benefits occur. Such a situation can arise where a completely closed vegetation canopy screens the ditch or natural stream channel.* The resultant lack of light penetration would reduce the growth of aquatic vegetation. In streams with smooth sandy bottoms lacking in obstructions, the detritus is not trapped in sufficient amounts to provide an alternative food source for fish in the absence of aquatic vegetation. Consequently, such ditches or streams would have a very sterile bottom and low productions of fish. Drain reconstruction

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*Personal communication from H. J. Manson, Fisheries Biologist, Ministry of Natural Resources, Simcoe District.

Table 6.1

A COMPARISON OF PHYSICAL PARAMETERS AND THE STANDING CROP OF BROOK TROUT BETWEEN DITCHED AND NATURAL SECTIONS OF MASSECAR CREEK, NORFOLK COUNTY (after Manson, 1972)

MASSECAR CREEK	NATURAL STREAM SECTION	DITCHED SECTION
LENGTH OF TEST SECTION (FEET)	600	600
MEAN WIDTH (FEET)	7.2	13.4
MEAN DEPTH (FEET)	0.7	0.6
% ESCAPE COVER	6.0	0.0
POUNDS TROUT/ACRE	11.0	0.0

Table 6.2

A COMPARISON OF AMOUNT OF ESCAPE COVER AND STANDING CROP OF TROUT IN DITCHED AND NATURAL STREAM SECTIONS IN NORFOLK COUNTY (after Manson, 1972)

STREAM NAME	NATURAL STREAM SECTION			DITCHED STREAM SECTION		
	LENGTH OF SECTION (ft.)	% ESCAPE COVER	lbs./ACRE TROUT	LENGTH OF SECTION (ft.)	% ESCAPE COVER	lbs./ACRE TROUT
HAY CREEK	300	10	49.8	300	1	0.6
SOUTH CREEK	100	9	31.7	100	1	2.6

or stream channelization removes the bank vegetation allowing light penetration. After a period of time aquatic vegetation would develop and the stream might ultimately support more fish.

There appears to be considerable variation in the rate of recovery of a channelized stream or drainage ditch after dredging activity. Extremely long lasting adverse effects on fish habitat have been reported from Idaho, where stream sections altered 30 to 75 years ago still produce approximately 80 to 90 per cent fewer pounds of game fish than undisturbed areas of the same stream (Woodsworth, 1971). Tarplee et al., (1971) indicate that nature can restore a stream and its fish population to pre-channelization levels in approximately 15 years provided no further disturbance of the stream habitat occurs. The South Creek drain in Middleton Township, Norfolk County, Ontario was last dredged in 1964 and by 1972 it had recovered sufficiently to provide a reasonably good habitat for trout (Manson, 1972).

The period necessary for recovery of fish populations can be shortened considerably if artificial restocking is carried out once the aquatic habitat has returned to a suitable level. In Norfolk County, it has been estimated that an average of about three to four years after ditching is required for the drain to recover sufficiently to enable restocking with trout fingerlings (H. Manson, Pers. Comm.). During this time period there is some development of aquatic vegetation and the banks become almost completely revegetated, thus reducing erosion and sediment load. Our investigations in West Luther Township, Wellington County indicate that after five to seven years bank vegetation covered greater than 75 per cent of the bank surface and the drain contained considerable aquatic weed growth.

Land drainage also creates detrimental effects on stream biology downstream from the actual construction site. These adverse effects are created by a rise in water temperature resulting from the removal of bank vegetation in the ditched sections, and by the increased sediment load.

Sediment may affect fish either by damaging the organisms directly or by damaging the habitat in which the organisms live (Ritchie, 1972). It is generally accepted that for sediment to have a direct effect on fish, the concentration must be very high. Wallen (1951) investigated the effect of erosion silt on a number of species of North American fish and found that they could tolerate turbidities of up to 100,000 PPM for a week or longer but the same fish died at turbidities above 175,000 PPM. Herbert and Merkens (1961) noted little effect of turbidity on trout at 0, 30 and 90 parts per million yet more than half of the fish died when turbidity reached 270 and 810 parts per million. Examinations showed lesions and thickening of gill tissues in most of the fish. Direct physiological damage to fish as a result of high sediment load created by ditch activity is probably limited, since fish can withstand high turbidity for short periods and can move to areas of lower turbidity.

Sediment can damage the aquatic habitat in a number of ways which affect fish populations. Reduction of light penetration can be considerable and the consequent inhibition of photosynthesis will result in less abundant food for fish (Ellis, 1937). Sediment may be deposited on stream bottoms covering spawning beds which reduces the survival rates of eggs and alevins dramatically (Cordone and Kelley, 1961). Hassler (1970) reported 97 per cent mortality among northern pike eggs covered with one millimeter of silt. Sediment may also reduce available food for fish by killing many bottom living organisms (Apmann and Otis, 1965).

Fish which are cold-blooded animals are unable to regulate their body temperature and are therefore particularly sensitive to changes in water temperature. A considerable amount of information is available on how temperature affects the live processes of fish. Most of the effects stem from the impact of temperature on the rate of metabolism which is speeded up by heat; normally the metabolic rate doubles with each increase of 18 degrees farenheit in water temperature (Clark, 1969).

A rise in metabolism increases the need for oxygen and consequently the rate of respiration must rise. At high temperatures an additional problem arises because the haemoglobin of the fish's blood has a reduced affinity for oxygen and becomes less efficient in delivering oxygen to the tissues. The combination of increased need for oxygen and reduced efficiency of obtaining it at rising temperatures can put severe stress on fish. Evidence is accumulating to show that temperatures which are not so high as to cause death may have very adverse effects on the life of fish. In experiments on food consumption in brook trout in which live minnows were used as food, it was found that the trout were comparatively slow in catching the minnows at 17 degrees centigrade and virtually incapable of doing so at 21 degrees centigrade (Baldwin, 1957). It has been found that brown trout grow more rapidly in cool water (Brown, 1946). Temperature also plays a critical role in the reproduction of aquatic organisms. Excessive temperatures can prevent normal development of eggs and there are critical limits above which fish will not reproduce.

It is possible the effects of ditching on stream temperature and sediment load further downstream may have a more serious impact on fish populations than the direct disturbance at the actual work site. This is

particularly true in situations where the municipal drains form the uppermost reaches of a stream system and do not themselves contain significant fish populations. For example, a recent evaluation of the effects of a proposed reconstruction of the Rocklyn Creek drain in Euphrasia Township, Grey County, Ontario on an important sport fishery expresses concern at the potential downstream effects of increases in water temperature and sediment on brook trout and rainbow trout spawning beds, which occur several miles below the site of the drainage project (Whitney and Westman, 1972).

Unfortunately there has been a lack of research on the distances that sediment and temperature changes are transmitted from sites of ditching. These downstream distances will of course vary considerably in relation to a number of factors such as stream discharge, extent of augmentation of stream flow by ground water, channel form and gradient, and character of bank vegetation. Warm water can be cooled as it passes through shaded areas downstream. Stoeckeler and Voskuil (1960) report that the passage of an open exposed trout stream in Wisconsin through the shade of a willow grove reduced late afternoon summer water temperature by 10 to 11 degrees farenheit. Further research on the transmission of sediment and temperature changes downstream from drain construction sites would obviously be desirable in order to assess the extent of adverse effects on stream ecology arising from land drainage projects.

6.6 Wetlands as Pollution Filters

The construction of municipal drains may produce additional effects on stream water chemistry when marshes and certain other types of wetland are involved in the drainage project.

Some research has been carried out in recent years on the beneficial and detrimental effects of marshes on water quality. The most comprehensive

tion which is carried on by various types of micro-organism within the marsh. This denitrification takes place when very low or zero oxygen concentration is present. These anaerobic conditions may occur for most of the year in areas of the marsh where there is an absence of water movement (Sparling, 1966). Very low disolved oxygen concentrations are also characteristic of the winter period in marshes where an ice cover is present. This transformation is important because it changes nitrogen from a plant useable form to a gaseous form which is not utilizable by plants.

The importance of wetlands in storing and transforming nutrients is indicated by a recent analysis of the phosphorous budget in the Lake Minnetonka watershed in Minnesota (Harza Engineering, 1971). The results of this study suggest that often 50 to 60 per cent of the phosphorous in stream water is removed primarily by marshes before the streams enter the lake.

Marshes reduce the velocity of water flowing into them from streams. The water is often spread over a wide area and filters slowly through areas of aquatic vegetation. This situation results in the deposition of large amounts of sediment before the water is discharged from the marsh. The trapping of sediment by the marsh is important for a number of reasons. The sediment itself can be detrimental to aquatic ecosystems. (see p. 130). Furthermore, sediment acts as a significant carrier of nutrients and pesticides which can be harmful to aquatic organisms and to human utilization of stream and lake waters.

Wetlands may also serve as sinks for heavy metals. An analysis of the horizontal and vertical distribution of land in a Connecticut salt

marsh revealed that concentrations in the surface layer decreased from approximately 179 to 198 PPM in the vicinity of storm drain outlets from adjacent urban areas, to levels of approximately 80 PPM in the areas furthest from the urban complex (Siccama and Porter, 1972). This data suggests that the marsh was effective in removing lead from inflowing waters and that this lead is accumulating in the marsh environment. A study of the pollution of rivers in West Wales, Great Britain by lead and zinc mine effluent also indicated that the salts of these metals, carried by the Teify River, were adsorbed as the water flowed through the peat of the Tregaron Bog (Newton, 1944).

Wetlands may also have detrimental effects on water quality mainly because of increased levels of organic materials which are found in waters discharging from wetlands. These organic materials derived from the breakdown of decaying vegetation increase the colour and the COD* values in discharged waters. Increased colour in water would make it unsuitable for drinking purposes as well as for a variety of industrial purposes. High colour levels also have a damaging effect on aquatic organisms reducing the penetration of solar radiation and therefore the amount of photosynthesis. At certain times of the year the discharge of water from wetlands may contain very low amounts of dissolved oxygen due to utilization by bacteria for respiration purposes.

A recent investigation of the effects of the drainage and conversion of a marsh to agricultural use suggests that drainage eliminates all of the beneficial effects of the wetland on water quality and may increase the

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* COD = chemical oxygen demand which gives an indication of the amount of chemically oxidizable organic matter present in water.

detrimental effects. An area of approximately 100 acres of land underlain by a tile drainage system and producing crops of carrots and onions was studied on the Shakey Marsh near Randolph, Wisconsin. The results of this study indicated an increase in colour and the organic matter content of the water. However, the most significant effect was a large increase in the release of various nitrogen and phosphorous compounds. On the basis of these results it has been estimated that the release of phosphorous from an acre of drained marsh may exceed by 50 times the contribution of an acre of average agricultural land in Wisconsin over a several year period (Lee, Bentley and Amundson, 1973).

6.7 Ecosystem Diversity and Stability

In the agricultural landscapes of southern Ontario the main remnants of semi-natural vegetation are found in the woodlots and wetlands. These areas maintain some of the complexity of original ecosystems and form habitats for a wide variety of organisms which would not survive in open agricultural fields.

Wetlands in particular are characterized by a rich variety of organisms and habitats. Some idea of the habitat diversity can be gained from analysis of wetland areas in the province. Tiny Marsh in Simcoe County comprises areas of open fresh water, deep fresh marsh, shallow fresh marsh, fresh meadows, shrub swamp, wooded swamp and bog (Wainio *et al.*, 1973). Similar varieties of habitats have also been encountered in other wetland areas in the province (Dale and Hoffman, 1969). This mixture of habitats over small areas is one of the main reasons for the diversity of wildlife associated with wetlands.

It is obvious that elimination of these wetlands by drainage will further reduce the diversity of organic life in rural areas. There is a considerable consensus among ecologists that a high diversity of organic life within the landscape tends to promote ecological stability. Stability in this context means that the system is relatively constant through time in terms of the variety of species present and their population sizes. In other words there is an absence of explosions in native populations and the system also tends to resist the invasions of organisms from other areas (Elton, 1958, page 145).

A large variety of organisms within an ecosystem implies that there should be a considerable number of interactions between them. Linkages between predator and prey are particularly important. When predators eat a variety of prey species, the presence of many prey populations may help to ensure that when one prey is temporarily low in numbers, the predators can turn to others and so maintain a high potential for attack, rather than becoming rare and allowing prey populations some of which may be agricultural pests to explode in size. (Murdock, 1971).

The view that stability is correlated with diversity has become something of a cliché. Recent research has indicated that the relationship is complex and not related solely to the number of interactions between organisms (Watt, 1964; Hairston et al., 1968). It is therefore probably wiser to regard the correlation between complexity and stability as a tentative hypothesis rather than an axiom. Nevertheless, it appears wise to retain areas of diversity within the agricultrual landscape and refrain from carrying simplification in the interests of increased agricultural intensity to an extreme level.

6.8 The Present Situation in Ontario

Various types of evidence have been used to evaluate the current extent and seriousness of the effects of land drainage on the environment. All the briefs submitted to the Select Committee on Land Drainage have been examined in order to gain an impression of the nature and frequency of environmental effects. A considerable number of interviews have been carried out with individuals in the Ministry of Natural Resources District Offices, the Canadian Wildlife Service, Conservation Authorities and universities. These interviews have given some indication of regional variations in levels of environmental impact in the province and have pinpointed examples of drainage projects which have had an adverse effect on the environment. A number of such examples have been examined in the field by the authors of this report.

The detailed questionnaire survey which was carried out on five drains in each of seven Townships in different areas of Ontario provides some information on the effects of drainage on vegetation and wildlife. Further assessment of the situation in these townships was carried out by comparing air photograph mosaics dating from 1955, at a scale of four inches to one mile, with recent air photographs flown in 1971 and 1972. Changes in the amount of permanent wetland, woodland and channelized streams were noted for this 17-year period.

It is difficult to make a precise evaluation of the environmental consequences of land drainage in Ontario. The survey of seven townships undertaken by the researchers forms a very small sample on which to base an assessment of the province-wide situation. The smallness of the sample however, may be mitigated to some extent by the fact that the seven

townships were chosen to give coverage to all the major regions of Ontario, and the sample is biased towards an overrepresentation of areas in which impacts on natural vegetation and wildlife might have been expected to occur. It is difficult to adequately compare the findings in these townships with other parts of the province because of the almost complete absence of detailed research on the environmental aspects of land drainage in Ontario. In this respect the researchers had to rely primarily on interviews with a wide range of experts.

In the absence of research in Ontario there has been a tendency to discuss the environmental impacts of land drainage on the basis of published research from the United States. If such comparisons are to hold any validity there must be a strong similarity between the characteristics of land drainage projects in Ontario and elsewhere in North America.

A number of the land drainage projects in the United States which have been publicized in recent years are major schemes. For example, a project consisting of 241 miles of channelization, realignment and enlargement of existing rivers and old ditches involving nearly 200,000 acres of wetland has been initiated in the Obion-Forked Deer Basin, in Tennessee (Barstow, 1971). In Minnesota between 1962 and 1965 approximately 60 miles of stream channel was excavated on the Hawk Creek and Chetomba Creek in order to reduce flooding on farms in the vicinity of these streams (Choate, 1971).

In some parts of the United States, notably in the Southeast, agricultural land drainage is expanding at a very rapid rate, and large areas of land are being drained for the first time. The rate of stream

channelization has accelerated very rapidly since 1954 under the Watershed Protection and Flood Prevention Act (Public Law 83-566). The extent of drainage of non-agricultural land and its conversion to farming can be illustrated by a variety of statistics. In Minnesota and the Dakotas between 1959 and 1966 an average of 138,000 wetland acres were drained each year, while approximately 80,000 acres of marshes in the 60 most important waterfowl producing counties of Minnesota and North Dakota were privately drained in the period 1966 to 1968 (Aus, 1969).

Considerable contrasts are apparent between the characteristics of drainage projects in certain parts of the United States and the situation in Ontario. On the basis of our analysis of drains in seven Townships and discussions with a variety of individuals involved with drainage in various parts of Ontario, it is evident that most drainage projects in recent years have been relatively small in size. Characteristically drains are approximately two to three miles in length, and the acreage of land involved in the assessment of benefit and outlet is between 500 and 1500 acres. There are a few examples of much more ambitious drainage schemes in Ontario, for example the Holland Marsh, but most of these date from before the Second World War. Other circumstances being equal, small drainage projects are unlikely to have the same magnitude of environmental impact as large projects, although the cumulative effect of many such schemes can have serious effects.

In view of the very large increases of expenditure on both municipal and tile drainage which have occurred between 1967 and 1971 in Ontario, it might be expected that extensive areas of land are being drained for the first time and converted into agricultural use. An analysis of

engineers reports for approximately 140 drains in the seven townships scattered across the province revealed very few new drains. The vast majority of the drainage projects involved the reconstruction of existing drains, although in some cases the drain was extended and new branches were added. It should be pointed out that on the basis of existing township records it is often difficult to judge whether the drain is new or not. Engineers reports frequently indicate that the drain is new when its status changes from an award drain to a petition drain. In situations where the drain reconstruction involves dredging of an old drain which has been neglected for a long time, the environmental consequences may differ very little from a situation where the land is drained for the first time.

It has been indicated in the first section of this chapter that many of the most detrimental impacts of land drainage occur when wetlands are drained and converted to agricultural purposes. Serious adverse consequences can also result from the channelization of permanent streams.

Air photographs dating from 1955 and the 1971-72 period were examined for the six sample townships in southern Ontario investigated in this report.* The disappearance of areas of permanent wetland woodlots, as well as changes in the extent of channelized permanent streams, were recorded for this 17-year period. (Table 6.3). Virtually no disappearance of permanent wetlands or woodlots was noted in West Luther and Ramsay Townships, while one small woodlot of approximately eight acres was cleared in

*No recent air photographs were available for Caldwell Township in Northern Ontario.

TABLE 6.3.

CHANGES IN THE AMOUNT OF WOODLAND, PERMANENT WETLAND AND CHANNELIZED STREAMS BETWEEN 1955 and 1971-72

TOWNSHIP	LOSS OF WOODLAND AND PERMANENT WETLANDS	INCREASE IN LENGTH OF CHANNELIZED STREAMS
WEST LUTHER (WELLINGTON COUNTY)	-	-
CUMBERLAND (OTTAWA-CARLETON REGION)	8 acres	1.5 miles
RAMSAY* (LANARK COUNTY)	-	-
ELLICE (PERTH COUNTY)	118 acres	-
BROOKE (LAMBTON COUNTY)	98 acres	1.7 miles
MERSEA (ESSEX COUNTY)	387 acres	0.2 miles

*Recent air photographs were only available for the eastern half of Ramsay Township.

Cumberland. The greatest clearance of woodland in this period occurred in Mersea where 27 woodlots totaling approximately 400 acres in area were cleared; lesser acreages of 120 acres in Ellice and 100 acres in Brooke were also converted to agricultural use. Disappearance of woodland in these townships could not be attributed solely to agricultural land drainage. Significant acreages of timber which do not require drainage are cleared in intensively farmed areas in order to expand the acreage of arable land. Nevertheless, approximately one-half and two-thirds of the woodland cleared in Mersea and Brooke respectively was adjacent to drains, and it is therefore likely in these cases that removal of water from the timber acted as an incentive to convert these acreages to intensive agricultural use.

Little increase in channelized streams was observed in any of the six townships for the period 1955 to 1971-72. In Cumberland and Brooke a total of approximately one and a half miles of channel was straightened on a number of small stream sections. This channelization may have resulted from land drainage activities, though in some cases highway construction appeared to be responsible. The evidence in these six townships suggests that the loss of permanent wetlands, woodlots and natural streams has generally been small, despite the very large increase in drainage grants during the late 1960's. The greatest change has occurred in south-western Ontario, particularly in Mersea Township, and may be explained by the high level of farming intensity in this region which has provided an incentive to increase the area of agricultural land. In eastern Ontario (Ramsay and Cumberland Townships) and the Dundalk Till Plain (West Luther Township), agriculture is less intensive and profitable and there is little

incentive to convert wetlands and woods to agricultural use. In fact in these areas the acreage of agricultural land has declined as marginal areas have been abandoned in recent years.

Examination of the detailed interviews conducted on 37 drains in the seven townships gives an indication of some of the consequences of drainage on the local environment. (Table 6.4). No attempt was made to investigate the larger scale regional impacts of these drainage projects on stream hydrology, and wildlife outside the drain area. The interview data must be interpreted with some caution, since they involve the subjective judgments of individuals who have a variable knowledge of various facets of the environment. The questionnaire focused primarily on small game, fur bearers and sports fisheries, and therefore judgments on the effects of drainage are limited to these organisms. Bearing in mind these limitations, the interviews suggest that the majority of drains analyzed had no discernible effect on the non-agricultural aspects of the local landscape. The numbers of small game and fur bearers together with the level of hunting and trapping appeared to be unaffected by drain reconstruction in most cases. Most of the drains analyzed contained insignificant fish populations and did not provide any sports fishing either before or after ditching. No evidence was found of changes in well water levels which could be attributed to the effects of drainage projects on the water table.

In a few cases adverse effects were observed. The reconstruction of the Stevens-Zavitz drain in Brooke Township involved the drainage of a small 12 acre marsh which resulted in the disappearance of ducks, muskrats, raccoons and amphibians from the site. Five or six people a year hunted

TABLE 6.4 Pg. 145

CUMBERLAND

NAME OF DRAIN	SMITH-STAEL	LALANDE-CLEROUX	ROBERT WALSH	VAN VLIET	CHARTRAND
CHANGES IN WELL LEVELS	—	—	—	—	—
ACRES OF SWAMP OR MARSH DRAINED	40	—	12	7	—
ACRES OF WOODLOT CLEARED	—	—	—	—	—
TYPES OF WILDLIFE BEFORE DRAIN PROJECT	Muskrat beaver, duck	Muskrat some beaver	Muskrat	Rabbit, duck beaver raccoon pheasant	Muskrat raccoon some rabbits
CHANGES IN WILDLIFE AS A RESULT OF DRAIN PROJECT	No change	No change	No change	No change	No change
NO. OF HUNTERS PER YEAR BEFORE DRAIN PROJECT	Some duck hunting	—	—	5-15	—
AFTER DRAIN PROJECT	Some duck hunting	—	—	5-15	—
TYPES OF FISH IN DRAIN BEFORE PROJECT	—	—	—	—	—
CHANGES IN FISH AS A RESULT OF PROJECT	—	—	—	—	—
NO. OF FISHERMEN PER YEAR BEFORE DRAIN PROJECT	—	—	—	—	—
AFTER DRAIN PROJECT	—	—	—	—	—
TRAPPING OF FUR-BEARERS BEFORE DRAIN PROJECT	Some beaver trapping	—	—	—	—
AFTER DRAIN PROJECT	Some beaver trapping	—	—	—	—
CHANGE IN AMOUNT OF TRAPPING AS A RESULT OF DRAIN PROJECT	No change	—	—	—	—

RAMSAY

NAME OF DRAIN	MUNRO	DUNCAN	CARL FOSTER	CURRIE	ALMONTE
CHANGES IN WELL LEVELS	—	—	—	—	—
ACRES OF SWAMP OR MARSH DRAINED	—	5	5	3	1
ACRES OF WOODLOT CLEARED	—	—	—	—	—
TYPES OF WILDLIFE BEFORE DRAIN PROJECT	rabbit beaver muskrat	duck geese Hu. partridge muskrat beaver	rabbit raccoon	rabbit deer beaver duck muskrat	muskrat beaver duck
CHANGES IN WILDLIFE AS A RESULT OF DRAIN PROJECT	No change	increase because of crop changes	No change	No change	No change
NO. OF HUNTERS PER YEAR BEFORE DRAIN PROJECT	—	—	—	Some hunting	—
AFTER DRAIN PROJECT	—	—	—	Some hunting	—
TYPES OF FISH IN DRAIN BEFORE PROJECT	—	—	—	—	—
CHANGES IN FISH AS A RESULT OF PROJECT	—	—	—	—	—
NO. OF FISHERMEN PER YEAR BEFORE DRAIN PROJECT	—	—	—	—	—
AFTER DRAIN PROJECT	—	—	—	—	—
TRAPPING OF FUR-BEARERS BEFORE DRAIN PROJECT	Some beaver trapping	—	—	—	—
AFTER DRAIN PROJECT	Some beaver trapping	—	—	—	—
CHANGE IN AMOUNT OF TRAPPING AS A RESULT OF DRAIN PROJECT	No change	—	—	—	—

TABLE 6.4 (Cont'd) Pg. 147
BROOKE*

NAME OF DRAIN	STEVENS-ZAVITZ	MUNROE	PARKER-LUCAS	GOVERNMENT NO. 1	TAIT
CHANGES IN WELL LEVELS	—	—	—	—	—
ACRES OF SWAMP OR MARSH DRAINED	12	—	—	—	4
ACRES OF WOODLOT CLEARED	—	4	—	5	—
TYPES OF WILDLIFE BEFORE DRAIN PROJECT	muskrat duck raccoon beaver	muskrat raccoon rabbit pheasant	rabbit muskrat raccoon deer (rare)	muskrat rabbit	duck rabbit pheasant raccoon muskrat
CHANGES IN WILDLIFE AS A RESULT OF DRAIN PROJECT	muskrat duck raccoon beaver not present now	reduction in no. of muskrat	No change	No change	less ducks
NO. OF HUNTERS PER YEAR BEFORE DRAIN PROJECT	5-6 (ducks)	25-30 (rabbit pheasant)	25 (rabbit)	—	5-10 (rabbit)
AFTER DRAIN PROJECT	None	20-30	25	—	5-10
TYPES OF FISH IN DRAIN BEFORE PROJECT	carp	carp pike (in spring)	suckers	—	—
CHANGES IN FISH AS A RESULT OF PROJECT	No carp	no carp or pike	suckers	—	—
NO. OF FISHERMEN PER YEAR BEFORE DRAIN PROJECT	—	—	—	—	—
AFTER DRAIN PROJECT	—	—	—	—	—
TRAPPING OF FUR-BEARERS BEFORE DRAIN PROJECT	—	Some muskrat trapping	—	Some muskrat trapping	Some muskrat trapping
AFTER DRAIN PROJECT	—	Some muskrat trapping	—	Some muskrat trapping	Some muskrat trapping
CHANGE IN AMOUNT OF TRAPPING AS A RESULT OF DRAIN PROJECT	No change	Less trapping	—	No change	No change

* Black Drain is a tile drain and is not included in the table.

TABLE 6.4 (Cont'd) Pg. 148

ELLICE*

NAME OF DRAIN	WHALING	SEIP	OHM	KUHRYVILLE	QUEREN-QUESSER
CHANGES IN WELL LEVELS	—	—	—	—	—
ACRES OF SWAMP OR MARSH DRAINED	—	10	—	—	25
ACRES OF WOODLOT CLEARED	—	—	—	—	—
TYPES OF WILDLIFE BEFORE DRAIN PROJECT	muskrat	muskrat	muskrat raccoon rabbit	muskrat rabbit pheasant	muskrat deer, rabbit raccoon pheasant partridge
CHANGES IN WILDLIFE AS A RESULT OF DRAIN PROJECT	No change	No change	No change	No change	No change
NO. OF HUNTERS PER YEAR BEFORE DRAIN PROJECT	—	—	12-15 (rabbit)	6 (rabbit)	10-12 (deer, rabbit)
AFTER DRAIN PROJECT	—	—	12-15	6	10-12
TYPES OF FISH IN DRAIN BEFORE PROJECT	—	—	—	suckers (in spring)	—
CHANGES IN FISH AS A RESULT OF PROJECT	—	—	—	No change	—
NO. OF FISHERMEN PER YEAR BEFORE DRAIN PROJECT	—	—	—	—	—
AFTER DRAIN PROJECT	—	—	—	—	—
TRAPPING OF FUR-BEARERS BEFORE DRAIN PROJECT	—	Some muskrat trapping	Muskrat trapping	Muskrat trapping	—
AFTER DRAIN PROJECT	—	None	Muskrat trapping	Muskrat trapping	—
CHANGE IN AMOUNT OF TRAPPING AS A RESULT OF DRAIN PROJECT	—	More trapping before	No change	No change	—

* Satchell Drain is a file drain and is not included in the table.

TABLE 6.4 (Cont'd) Pg. 149

MERSEA

NAME OF DRAIN	WILLIAM JAMES	WEST MARSH	STRAUSS LAND CO.	EXT. OF COULSON	ROBERT ANDERSON
CHANGES IN WELL LEVELS	—	—	—	—	—
ACRES OF SWAMP OR MARSH DRAINED	—	—	—	—	—
ACRES OF WOODLOT CLEARED	—	—	—	—	—
TYPES OF WILDLIFE BEFORE DRAIN PROJECT	muskrat pheasant rabbit duck raccoon	muskrat pheasant rabbit	rabbit pheasant	rabbit raccoon	muskrat rabbit pheasant
CHANGES IN WILDLIFE AS A RESULT OF DRAIN PROJECT	No change	No change	No change	No change	No change
NO. OF HUNTERS PER YEAR BEFORE DRAIN PROJECT	15-20 (pheasant rabbit)	—	2-3 (rabbit	—	5-6 (pheasant)
AFTER DRAIN PROJECT	15-20	—	2-3	—	5-6
TYPES OF FISH IN DRAIN BEFORE PROJECT	carp pike	carp pike	—	—	—
CHANGES IN FISH AS A RESULT OF PROJECT	No change	No change	—	—	—
NO. OF FISHERMEN PER YEAR BEFORE DRAIN PROJECT	—	10-20 (carp)	—	—	—
AFTER DRAIN PROJECT	—	10-20	—	—	—
TRAPPING OF FUR-BEARERS BEFORE DRAIN PROJECT	some muskrat trapping	some muskrat trapping	—	—	—
AFTER DRAIN PROJECT	some muskrat trapping	some muskrat trapping	—	—	—
CHANGE IN AMOUNT OF TRAPPING AS A RESULT OF DRAIN PROJECT	Less trapping	Less trapping			

WEST LUTHER

NAME OF DRAIN	NO. 56	NO. 50	NO. 1 & 4	NO. 52	NO. 53
CHANGES IN WELL LEVELS	—	—	—	—	—
ACRES OF SWAMP OR MARSH DRAINED	8	13	45	—	26
ACRES OF WOODLOT CLEARED	—	—	10	—	—
TYPES OF WILDLIFE BEFORE DRAIN PROJECT	muskrat mink duck rabbit raccoon	muskrat partridge rabbit duck deer	muskrat rabbit deer duck raccoon mink	—	muskrat duck deer rabbit raccoon mink
CHANGES IN WILDLIFE AS A RESULT OF DRAIN PROJECT	muskrat duck reduced in numbers	No change	No change	—	No mink now
NO. OF HUNTERS PER YEAR BEFORE DRAIN PROJECT	2-4 (duck rabbit)	—	10-15 (duck rabbit)	—	15-20 (rabbit)
AFTER DRAIN PROJECT	2-4	—	10-15	—	15-20
TYPES OF FISH IN DRAIN BEFORE PROJECT	—	—	—	—	—
CHANGES IN FISH AS A RESULT OF PROJECT	—	—	—	—	—
NO. OF FISHERMEN PER YEAR BEFORE DRAIN PROJECT	—	—	—	—	—
AFTER DRAIN PROJECT	—	—	—	—	—
TRAPPING OF FUR-BEARERS BEFORE DRAIN PROJECT	Some muskrat trapping	Some muskrat trapping	—	—	—
AFTER DRAIN PROJECT	Some muskrat trapping	—	—	—	—
CHANGE IN AMOUNT OF TRAPPING AS A RESULT OF DRAIN PROJECT	No change	Trapping ceased	—	—	—

TABLE 6.4 (Cont'd) Pg. 151

CALDWELL

NAME OF DRAIN	ARBOUR	RAINVILLE	CLEMENTS	LAFERRIERE	SAVAGE
CHANGES IN WELL LEVELS	—	—	—	—	—
ACRES OF SWAMP OR MARSH DRAINED	—	—	—	—	—
ACRES OF WOODLOT CLEARED	—	—	—	—	—
TYPES OF WILDLIFE BEFORE DRAIN PROJECT	rabbit muskrat beaver	rabbit	muskrat beaver	muskrat beaver rabbit	beaver muskrat
CHANGES IN WILDLIFE AS A RESULT OF DRAIN PROJECT	No change	No change	No change	No change	No change
NO. OF HUNTERS PER YEAR BEFORE DRAIN PROJECT	—	—	6	3-4	—
AFTER DRAIN PROJECT	—	—	6	3-4	—
TYPES OF FISH IN DRAIN BEFORE PROJECT	suckers pike (in spring)	—	—	—	—
CHANGES IN FISH AS A RESULT OF PROJECT	No change	—	—	—	—
NO. OF FISHERMEN PER YEAR BEFORE DRAIN PROJECT	—	—	—	—	—
AFTER DRAIN PROJECT	—	—	—	—	—
TRAPPING OF FUR-BEARERS BEFORE DRAIN PROJECT	—	—	Some muskrat trapping	Some muskrat trapping	—
AFTER DRAIN PROJECT	—	—	Some muskrat trapping	Some muskrat trapping	—
CHANGE IN AMOUNT OF TRAPPING AS A RESULT OF DRAIN PROJECT	—	—	No change	No change	—

duck on the marsh before drainage, and this activity has now ceased. Some reduction in numbers of muskrats and ducks were noted on the Munroe and Tait drains in Brooke Township and on drain number 53 in West Luther in the period after dredging. The Smith-Stael drain in Cumberland Township is a new drain for approximately two-thirds of its length and penetrates into the eastern portion of the Mer Bleue, a unique bog located within 10 miles of Ottawa. The effect of this drain on the vegetation and wildlife of the bog could have been serious. However, beaver dams on the Savage drain which lies to the west have resulted in water overflowing eastwards across the bog to the Smith-Stael drain, preventing agricultural use of the land on the west side of the drain. In a number of cases, particularly in West Luther and Cumberland, ditching took place in permanent wetland. Although these areas were usually not converted to agricultural use some adverse effects to vegetation and wildlife may have occurred as a result of the removal of standing water. It must be emphasized, however, that there is no evidence of these adverse consequences in the interviews with land owners.

In the seven townships which have been studied in detail it appears that recent drainage activity has not resulted in a major loss of natural habitats, and with a few exceptions there has not been a major reduction in small game animals and fur bearers in the vicinity of the drain. Caution must be exercised in transferring these conclusions, derived from seven townships, to the province as a whole. However, interviews with a variety of experts suggest a low rate of permanent wetland loss as a result of agricultural land drainage in the past decade. In the more urbanized portions of Ontario along the Toronto-Windsor axis the loss of

permanent wetlands as a result of urbanization and highway construction has been much more serious than the loss due to agricultural land drainage.

Two further points must be stressed with regard to agricultural drainage of wetlands. Although the overall rate of wetland loss in the province has been low in recent years, there are some areas in which the conversion of swamps and marshes to agriculture has been high. For example, the Stroud Swamp and portions of the Cookstown, Randall and Adjala Swamps in Simcoe County have been drained for use as market gardens and sod farms. Many potholes and wetlands in the townships north and west of Toronto have been drained to remove peat for commercial use in the last decade (Ministry of Natural Resources, 1973).

Furthermore, a low rate of wetland loss may still be very serious if it occurs in areas where there is a lack of wetland acreage. A survey based primarily on reports of the Ontario Soil Survey which dates mainly from the period 1950-1960 gives some approximate information about the extent of remaining wetland acreage in this period (Ministry of Natural Resources, 1973). In the 36 counties included in the assessment an average of only 50 per cent of the original wetlands remain, while in the intensively farmed counties of Essex and Kent wetlands have been reduced to approxmately ten per cent of their original total. This data suggests that even a low rate of permanent wetland loss may have a serious environmental impact, particularly on wildlife in parts of southwestern Ontario. Waterfowl would certainly be seriously threatened by any further reduction

in the number and sizes of marshes on the Great Lakes.* Such a reduction would result in very high densities of migrant waterfowl on a few marshes which could seriously increase their vulnerability to disease and to severe storms.

The views expressed regarding wetlands and wildlife are also relevant to stream channelization and sports fisheries. A small proportion of recent drainage projects have had serious adverse consequences for sports fisheries. Drain construction and stream channelization have damaged trout streams in Grey County and near Komoka and Strathroy in Middlesex County. (Ministry of Natural Resources, 1973). Data illustrating the impact of ditching on trout streams in Norfolk County have been presented in the first part of this chapter. (page 127). These adverse effects are particularly serious in areas where certain types of sports fishing are in short supply. In eastern Ontario there are very few cold water stream fisheries. The best stream in the region is actually a municipal drain (Allen's Drain, Mountain Township, Dundas County) which is stocked by the Ministry of Natural Resources.** If this stream undergoes reconstruction the sports fishery will be lost for a considerable time period. The detrimental effects of drainage activities on trout streams in Norfolk County is enhanced by the fact that this area contains the only cold water streams within the Lake Erie drainage basin.

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*Personal communication from D. Dennis, Canadian Wildlife Service, Aurora, Ontario.

**Personal communication from R. G. Baldwin, Ministry of Natural Resources, Cornwall District.

The effects of drainage activity on the physical hydrology of drainage basins in Ontario has been particularly difficult to evaluate. There is a lack of previous research on which to base such an assessment, and in the present project the researchers have not been able to document such impacts. However, several of the briefs presented to the Select Committee have indicated the potential serious impacts of extensive land drainage activity on flood flows and low flows (Ministry of Natural Resources, 1973; Grand River Conservation Authority, 1973).

In recent years the Conservation Authorities of Ontario have spent large sums of money on water management projects for flood control and low flow augmentation. These projects have included the construction of dams, reservoirs and flood control channels. The designs of these projects are such that in order for the programmes to achieve full effectiveness the hydrologic characteristics of the basin must remain relatively stable. Large numbers of drainage projects, particularly in water storage areas in the headwater sections of drainage basins, have considerable potential for offsetting the efforts of the Conservation Authorities to provide flood protection and to guarantee reasonable levels of low flow. The Dundalk Till Plain in Grey, Dufferin, Wellington and Simcoe Counties is an example of significant headwater region which has recently experienced the construction of a considerable number of drains which may affect the Saugeen, Grand and Nottawasaga Rivers (Whitney, Burdett and Hunt, 1972).

In attempting to assess the impacts of the great increase in drainage activity which has occurred since 1967, it is important to recognize that the full impacts on flood flows and low flow patterns are most difficult to evaluate. The nature of hydrologic events only occur occasionally, but

it is these occasional extremes such as a flood or drought, which can account for much damage. If drainage projects affect runoff patterns in such a way as to reduce the effectiveness of a flood control structure, an extreme flood event may cause excessive damage. While it is not possible to document the risks involved, this question deserves careful study and may be one of the most serious of all the environmental impacts of recent land drainage activity in Ontario.

Some consideration should be given to drain maintenance practices in assessing the environmental effects of land drainage at the present time. It has already been pointed out that the major portion of drainage grants in recent years has involved reconstruction of existing drains. General practice in most parts of the province has been to allow drains to deteriorate over a period of years, and then to undertake a major reconstruction. This practice may be inefficient in terms of providing for adequate removal of water from agricultural land, and may reduce agricultural benefits, while at the same time increasing the long-term costs of municipal drains. Paradoxically this practice probably has fewer adverse effects on the environment than most other methods of maintaining open drains. In the interval between reconstruction, which may vary from six to eight years in areas of sandy soil (Norfolk County) to 15 to 20 years in heavy clay soils (Kent County), the drain habitat may be utilized by various types of wildlife, and provides some hunting and fishing in parts of the province.

A number of briefs to the Select Committee on Land Drainage advocate changes in maintenance practices of drains. It has been suggested that streamlining of municipal drains would enable more efficient maintenance. At the present time several drains may empty into a common outlet with a

separate bylaw covering each drain. In this situation each drain is usually overhauled separately, often at different times. If these drains were combined into one drain system under one bylaw the whole system could be dredged out at the same time. This procedure might be more efficient from an agricultural viewpoint but would result in a greater adverse impact on wildlife and fisheries because of the larger area involved in reconstruction. It has also been suggested that drains should have small scale maintenances at frequent intervals of approximately two years which would involve removing silt from the drain and the clearance of aquatic and bank vegetation. It is claimed that this procedure would increase the efficiency of the drains and would considerably lengthen the time interval between massive drain reconstructions.* Unfortunately, this procedure would probably totally eliminate the usefulness of drains as a wildlife habitat because of the frequency of disturbances. In areas such as Norfolk County where a number of the drains contain trout populations and are utilized for sports fishing in the intervals between major reconstruction, the introduction of frequent maintenance would probably substantially reduce the trout population.

Experiments are currently being undertaken in Windham Township, Norfolk County on the use of vegetation to stabilize drain banks thus reducing maintenance costs and prolonging the life of the drain.**

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*Personal communication from D. Rogerson, Drainage Commissioner for Windham Township, Norfolk County.

**Personal communication from Professor E. Watkin, Department of Crop Science, University of Guelph.

The decrease in sediment loads in drains and permanent streams which would probably result from revegetation could reduce the adverse consequences of ditching on fish populations. However, the seeding mixtures, consisting mainly of grasses, will create a vegetation cover which will not offer a suitable habitat for many types of wildlife.

The views which have been expressed regarding the environmental impacts of recent land drainage in Ontario must be regarded as tentative in the absence of comprehensive research. It is necessary to establish an inventory of environmental resources in the province. Wildlife capability and suitability maps are now available and the Wildlife Branch of the Ministry of Natural Resources is currently studying ways of estimating actual numbers of important game animals associated with various types of habitat.* The Sports Fisheries Branch of the Ministry of Natural Resources is in the initial stages of a province wide assessment of streams.** An inventory should be made of the percentage of remaining permanent wetlands and the extent of stream channelization throughout the province. Inventories of the type described above are of the utmost importance because they will not only allow a more detailed assessment of the environmental consequences of future drainage projects, but also of many other types of human modification of the environment.

The environmental consequences of drain construction should be investigated by monitoring a number of projects before and after ditching. The work of Manson (1972) detailing the effects of ditching on trout

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*Personal communication from A. Hauser, Wildlife Branch, Ministry of Natural Resources, Queen's Park, Toronto.

**Personal communication from E. Cox, Sports Fisheries Branch, Ministry of Natural Resources, Queen's Park, Toronto.

populations appears to be the only study of this type which has been undertaken in Ontario. A high priority should also be given to research on the regional effects of land drainage on the physical hydrology of drainage basins.

6.9 Conclusions

The bulk of drainage activity in the last decade has involved the reconstruction of existing drains, rather than the drainage of large new areas of land. Consequently, the overall provincial rate of disappearance of permanent wetlands as a result of agricultural land drainage has been relatively small during recent years. Wetland loss however, has been considerably more rapid in a few areas, particularly in the counties to the north and west of Toronto.

The vast majority of drainage projects studied in this report did not appear to have a serious detrimental effect on natural vegetation and wildlife within the local drain area. However, a minority of agricultural land drainage projects do have a serious effect on the environment. Moreover, the cumulative effect of a number of drainage projects each of which individually has only a minor adverse effect on the environment may be serious in some parts of the province especially in those areas where the remaining supplies of permanent wetlands and natural streams are at a critical level.

The impact of individual drainage projects on stream hydrology is probably very small. However, the cumulative effect of a number of municipal drains and associated tile drainage systems within a drainage basin may have a considerable influence on flood peaks and other hydrological variables, as well as on water quality.

Basic research is urgently required in order to establish more clearly the magnitude of the environmental impacts, and to enable more objective decisions to be made on the merits of future drainage projects.

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Chapter 7

LAND-USE CONFLICTS RESULTING FROM DRAIN CONSTRUCTION

7.1 Introduction

A major concern of the Select Committee on Land Drainage, and of many persons or groups throughout the Province as evidenced by the briefs and hearings of the Committee, is land-use conflict resulting from the construction of agricultural drains. This chapter examines evidence accumulated by the researchers concerning two kinds of conflict alleged to be particularly prevalent--those in wetlands, and those along the interfaces between rural and urban areas.

7.2 Wetland Conflicts

Wetlands provide a classic case of conflict in resource utilization. To the farmer wetlands are often a nuisance causing delays and increasing costs of farm operations. They may also be regarded as areas of potentially rich unexploited agricultural land. Both of these viewpoints encourage wetland drainage and conversion to cropland. At the same time these wetlands, in an undrained condition, fulfill a wide variety of functions which are of considerable significance to the public interest. A growing awareness of the variety of wetland functions has resulted in an increase in the number of conflicts arising from agricultural drainage of these areas in Ontario.

A number of approaches have been adopted in reviewing the problems of competing land use in wetlands. Firstly, the various types of wetland and their major functions have been documented in order to emphasize the full range of competing land uses which can be involved. Many of these func-

tions have not been considered in recent wetland conflicts in Ontario. Secondly, the general characteristics of competing land uses in Ontario wetlands have been analysed by means of interviews with Ministry of Natural Resource personnel, engineers, agricultural representatives and others. A review has also been made of all the briefs submitted to the Select Committee on Land Drainage and of the hearings conducted by the committee. Finally, two drainage projects involving the most common types of wetland conflict in Ontario, have been examined in some detail. In these cases field surveys and interviews with landowners have been carried out in order to assess the agricultural benefits as well as the adverse effects on other wetland uses.

(a) natural functions and use-values of wetlands.

Wetlands vary in depth, durability and ecological characteristics. These distinctions are important because the economic feasibility of reclaiming land is dependent upon these characteristics. Moreover, wetlands of different types have differential significance for wildlife and a variety of other functions. In Ontario, the most common terms used to describe wetlands are marsh, swamp and bog.

There is some concensus among researchers that a marsh can be defined as an area that is temporarily or permanently covered with water. Trees are usually absent and the main types of vegetation are grasses, sedges and reeds. (Penfound, 1952; Heinselman, 1963). The term swamp has been used to loosely describe all types of wetlands, but can be defined more precisely as a wetland that supports tree vegetation (Vetch and Humphrey, 1966). Penfound (1952) divides swamps into two types, deep and shallow. Both types support tree vegetation, but in the deep swamp, standing water persists throughout most of the summer, whereas in the shallow type surface water is not present

during the growing season. The word bog is used in many different senses and sometimes includes marshes and swamps as well as true bogs. Dansereau and Segados-Vionna (1952) have reviewed a number of contrasts between bogs and swamps. They suggest that bogs are wet areas often dominated by heath vegetation and conifers, such as black spruce and underlain by a more or less continuous stratum of sphagnum moss. Unlike marshes or swamps, bogs usually contain few areas of open water.

An outline of the major functions of wetlands provides some indication of the conflicts of interest which can arise in relation to the use of these areas.

The agricultural potential of organic soils has been recognized for many years. The drainage of wetlands and their conversion to agricultural use has created a number of successful farming areas in Ontario, the most notable of which is the Holland Marsh, which produced over ten million dollars worth of vegetables in 1967 (Leeson, 1969). However, wetland drainage has also produced agricultural failures such as Luther Marsh in Wellington County and Tiny Marsh in Simcoe County.

Wetlands have also been drained in order to extract peat moss for utilization in agriculture, industry and the home. This practice is currently prevalent in townships near Toronto. In many cases wetlands are not converted to cropland, but are drained in order to improve adjacent agricultural areas.

In an undrained condition wetlands fulfill important hydrologic functions and may be significant as pollution filters. These roles have been discussed at some length in Chapter 6. The pollution filter function may take on added significance, if the wetland is located near an urban area, or is surrounded by agricultural land on which considerable quantities of fertilizer are used.

Wetlands provide essential habitats for a wide variety of wildlife. The significance of this role varies with wetland type. Small potholes and large permanent marshes are particularly important for waterfowl, whereas bogs are of little significance owning to a lack of open water areas. Many types of wildlife not normally associated with wetlands also depend on these areas for protection and cover at certain times of the year.

In many agricultural areas wetlands provide the only remnants of semi-natural habitat and thus act as reservoirs of biological complexity within a simplified landscape. Ecological theory suggests that the presence of a diversity of habitats and organisms is important in reducing the possibility of pest outbreaks. The arguments surrounding this role are complicated and research data are largely absent.

Wetlands are significant in providing certain types of recreation, particularly hunting, fishing and nature study. The importance of fishing and hunting as recreational pursuits can be gauged from the fact that in 1967 28 percent of the residents of Ontario fished and 13 percent hunted (Ministry of Natural Resources, 1973). The distribution of fishing and hunting activities in Ontario gives a good indication of areas where serious conflicts are likely to occur between recreation and agricultural demands for wetlands (Figs. 7.1 and 7.2). In 1971 there was a total of 86,691 waterfowl hunters in the Lake Simcoe, Lindsay, Aylmer and Lake Huron Districts.* Waterfowl hunting is obviously directly dependent on the availability of suitable wetlands. However, other types of hunting for deer, pheasant, Hungarian partridge, ruffed grouse and European hare, although they may not occur within wetlands, are nevertheless equally dependent on the existence of such areas, since wetlands provide

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*Statistics supplied by Ministry of Natural Resources.

Figure 7.1 Estimated participation in small game hunting, 1971

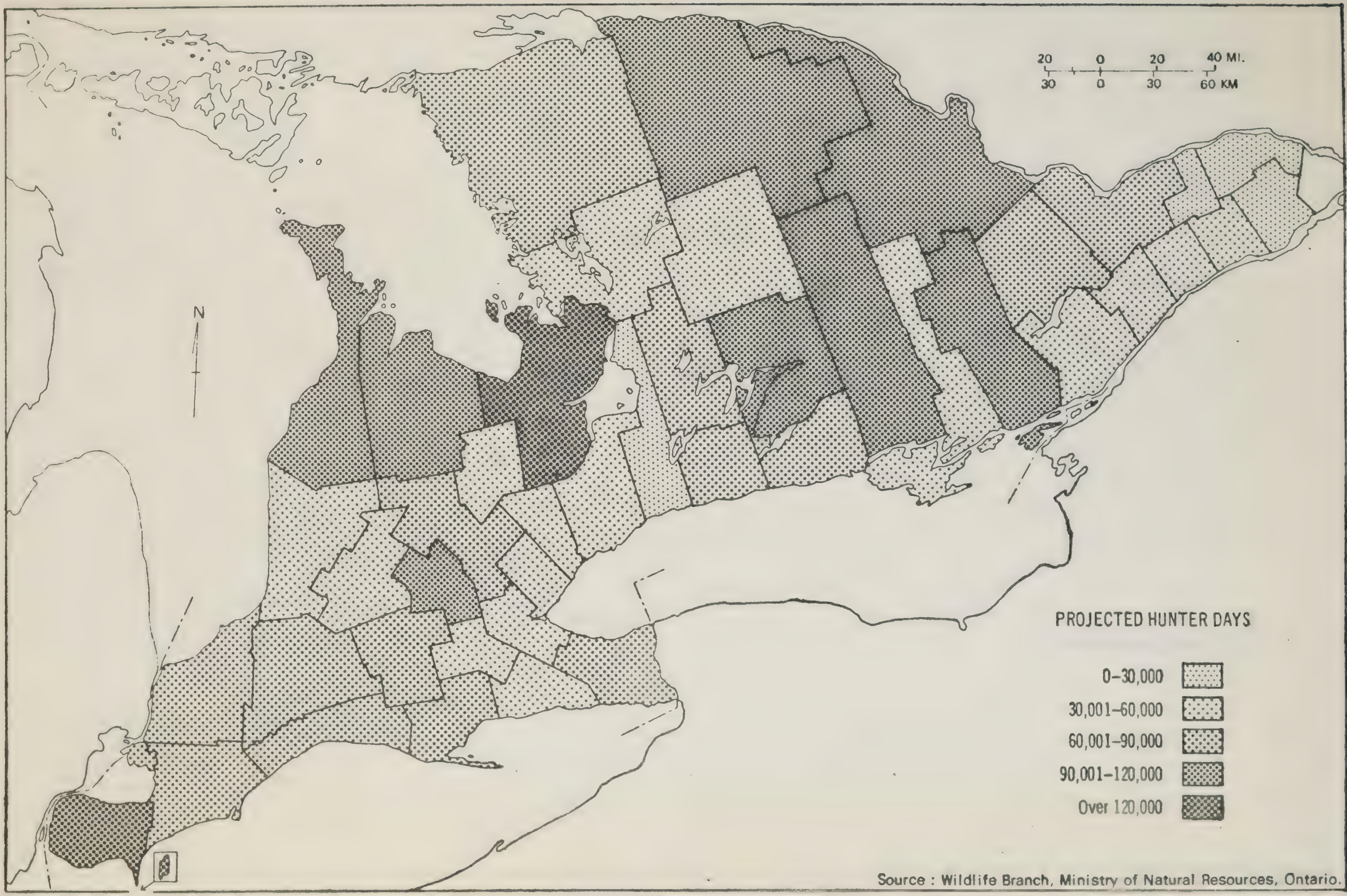
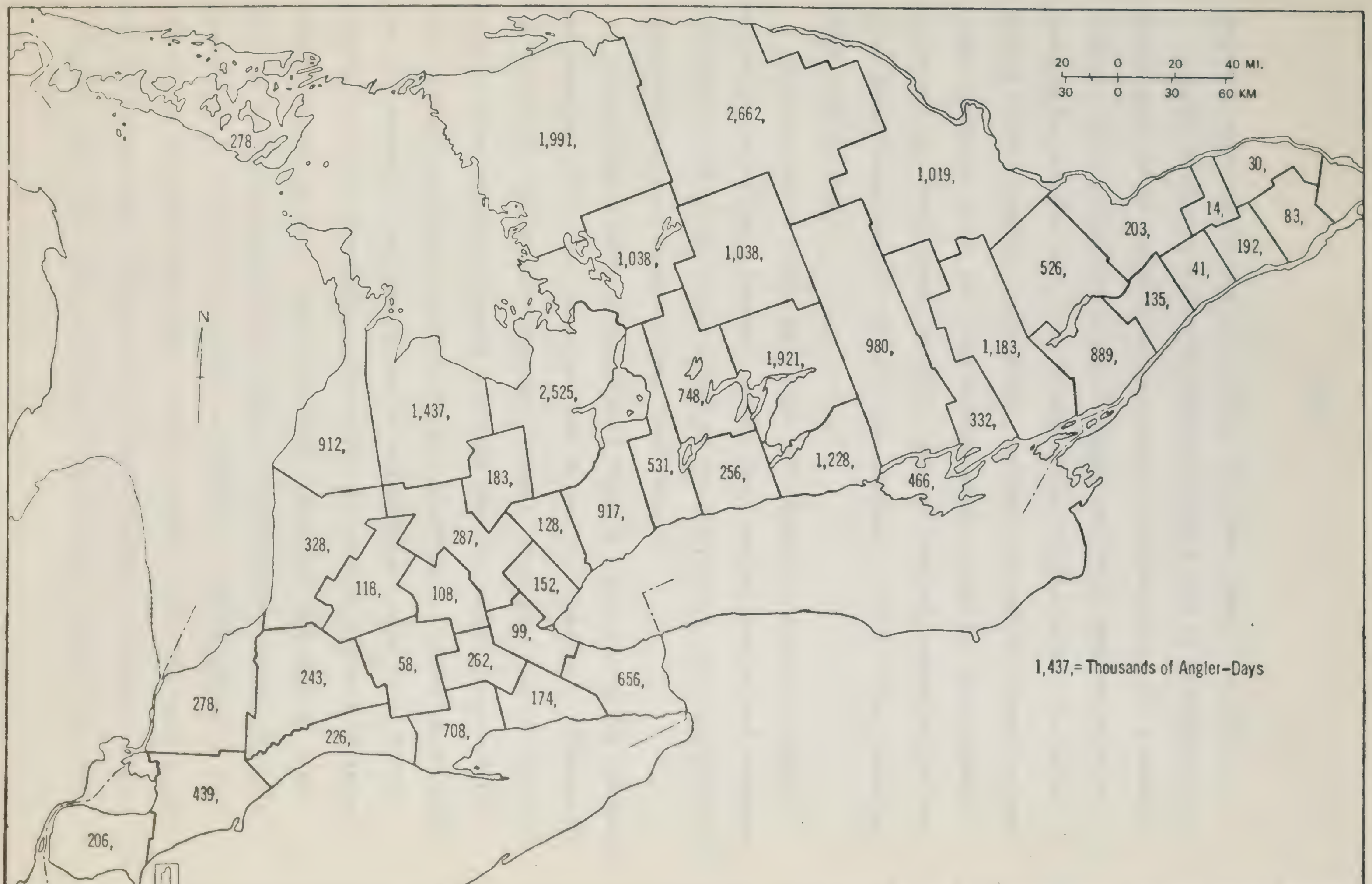


Figure 7.2 Estimated total angling in County and adjacent Great Lakes waters, 1971



Source : Sport Fisheries Branch, Ministry of Natural Resources.

necessary cover, particularly in winter, for these types of wildlife.

General wildlife-oriented recreation pursuits such as birdwatching and nature study are of considerable importance in wetland areas for a number of reasons. These areas often contain a large variety of habitats which encourages the presence of a much greater diversity of wildlife than areas of more uniform habitat. Furthermore, wetlands may contain unusual or rare plants (orchids, ferns, etc.) and animals which can not be found elsewhere in the region. For example, in 1963 a pair of Hawk Owls nested on the Mer Bleue near Ottawa, some 300 miles to the southeast of their normal breeding range. (Smith, 1970).

Wetlands are of little importance with respect to intensive types of recreation activities. Swimming, picnicking, camping, boating and cottaging are excluded due to the unsuitability of the environment, and the presence of large populations of mosquitoes and black flies.

Wetlands may provide a considerable range of opportunities for education and research. This function of wetlands is utilized relatively infrequently but can attain considerable importance in areas where wetlands are adjacent to large urban centres, or where a wetland has some unique characteristics which are not duplicated except at distant locations. It has been estimated that the swamps of the Alcovy River in Georgia have a value of $100,000 annually as a site for college field trips and graduate research (Wharton, 1970). The Mer Bleue, a unique bog which lies within ten miles of Ottawa, provides an outstanding area for research and education. It was the first location in North America for which an analysis of fossil pollen was made, and the bog has been extensively used for research by the two universities and various government departments in Ottawa (Baldwin and Mosquin, 1969). The Byron Bog which lies within the city limits of London, Ontario has also

proved invaluable as a study area for many groups including natural history clubs, students at the University of Western Ontario, and in primary and secondary schools (Judd, 1967).

Wetlands can have a considerable importance in enhancing the quality of life by providing an open space and aesthetic function. This role is an intangible one which is almost impossible to measure. Wetlands may supply areas of open space near urban centres which can be incorporated as an essential part of the developing community (Niering, 1970). It is also possible to suggest a number of aesthetic benefits which can be derived from these areas. In some types of wetland the association of diverse forms of vegetation interspersed with open water may create areas of scenic beauty. Another kind of scenic value is derived from the role of the wetland as a distinct landscape component and its contribution to landscape diversity in a region (Gupta, 1972).

Muskrat, beaver, mink, otter and to a considerable extent raccoons are associated with wetlands. The majority of furs harvested in Ontario are provided by these animals. In Aylmer, Hespeler, Lake Simcoe and Kemptville Districts alone, wetlands support a fur industry of between one half and one million dollars and provides supplementary incomes for 700 persons, of which about 20 percent are farmer-trappers (Ministry of Natural Resources, 1973).

Wetlands in Ontario are not usually of major importance for forestry purposes. Bog areas containing white cedar, aspen, tamarack and silver maple are of little value for the production of commercial forests. A survey of forested wetlands in Simcoe County indicated that these areas would be classified as class 6 or 7 because of the severity of their limitations for forestry (Leeson, 1969). Hardwood swamps are utilised for timber products

in areas of southwestern Ontario, but their value is much lower than upland hardwood stands dominated by sugar maple.

(b) analysis of wetland conflicts described in briefs and interviews.

A considerable number of briefs, particularly those submitted to the Select Committee by non-agricultural groups, make reference to the subject of wetland conflicts. However, neither in the briefs nor in the researchers' interviews has it been possible to find fully documented cases of conflicts in which detailed assessments have been made of the extent of damage to alternative land uses resulting from drainage of wetlands for agricultural purposes.

The evidence available does indicate the occurrence of a number of wetland conflicts, although these seem to make up a small percentage of the total number of recent drainage projects in the province. The extensive agricultural areas of Southwestern Ontario appear to have had relatively few wetland conflicts in the last decade, as would be expected in view of the small remaining percentage of wetland in this area. However, conflicts between waterfowl and agriculture are involved in the recent drainage of two marshes on Lake St. Clair.

Fears have been expressed regarding serious wetland conflicts on the Dundalk Till Plain in Grey, Dufferin, Wellington and Simcoe Counties (Whitney, Burdett and Hunt, 1972). Although little actual clearance of wetland is involved a number of recent drains pass through wetlands. Wetlands in this region are of considerable significance from a hydrological viewpoint, since the area serves as the headwaters for the Saugeen, Grand and Nottawasaga Rivers. Several thousand acres of forest, much of it wetland, have been purchased by Conservation Authorities for purposes of

preserving these headwater areas. Wetlands in this region are also significant for wildlife and wildlife-based recreation.

The counties to the north and west of Toronto appear to have experienced the highest rate of recent wetland disappearance in Ontario. In Simcoe County portions of the Stroud, Cookstown, Randall and Adjala Swamps have been drained for market garden crops and sod production. Many potholes and wetlands in this region have also been drained to remove peat for commercial use. These activities have adversely affected wildlife and recreational roles of wetland areas.

In eastern Ontario a few cases of wetland conflicts have been observed (Ministry of Natural Resources, 1973). A drain which has been installed in the Winchester Bog (Dundas County) appears to have damaged a Provincial Wildlife Area. Drains on the Alfred Bog have resulted in the drowning of deer and moose. Two drains which are in the proposal stage will damage waterfowl habitats in Limerick Forest and Wolford Bog.

(c) detailed case studies of wetland conflict.

The seven townships and sample drains selected for detailed study did not reveal any major example of a wetland conflict. A number of drains, particularly in West Luther, Cumberland and Ramsay did involve small acreages of wetland though none of these areas was converted to agriculture. There was no evidence that these drains precipitated any major disputes involving competing uses of the wetlands. It was therefore decided to examine two additional drainage projects which appear to involve major conflicts.

The drains were selected in order to represent the two categories of conflict which have received most attention in Ontario. The Martin Drain

involves a conflict between agricultural drainage and the water storage role of wetlands, whereas in the case of the 8th Line Municipal Drain the conflict involves wildlife and the recreational role of wetlands. These drainage projects were investigated in order to present a full assessment of all costs and benefits involved; and to give an indication of the extent to which the present Land Drainage Act deals adequately with these situations of competing land use.

MARTIN DRAIN

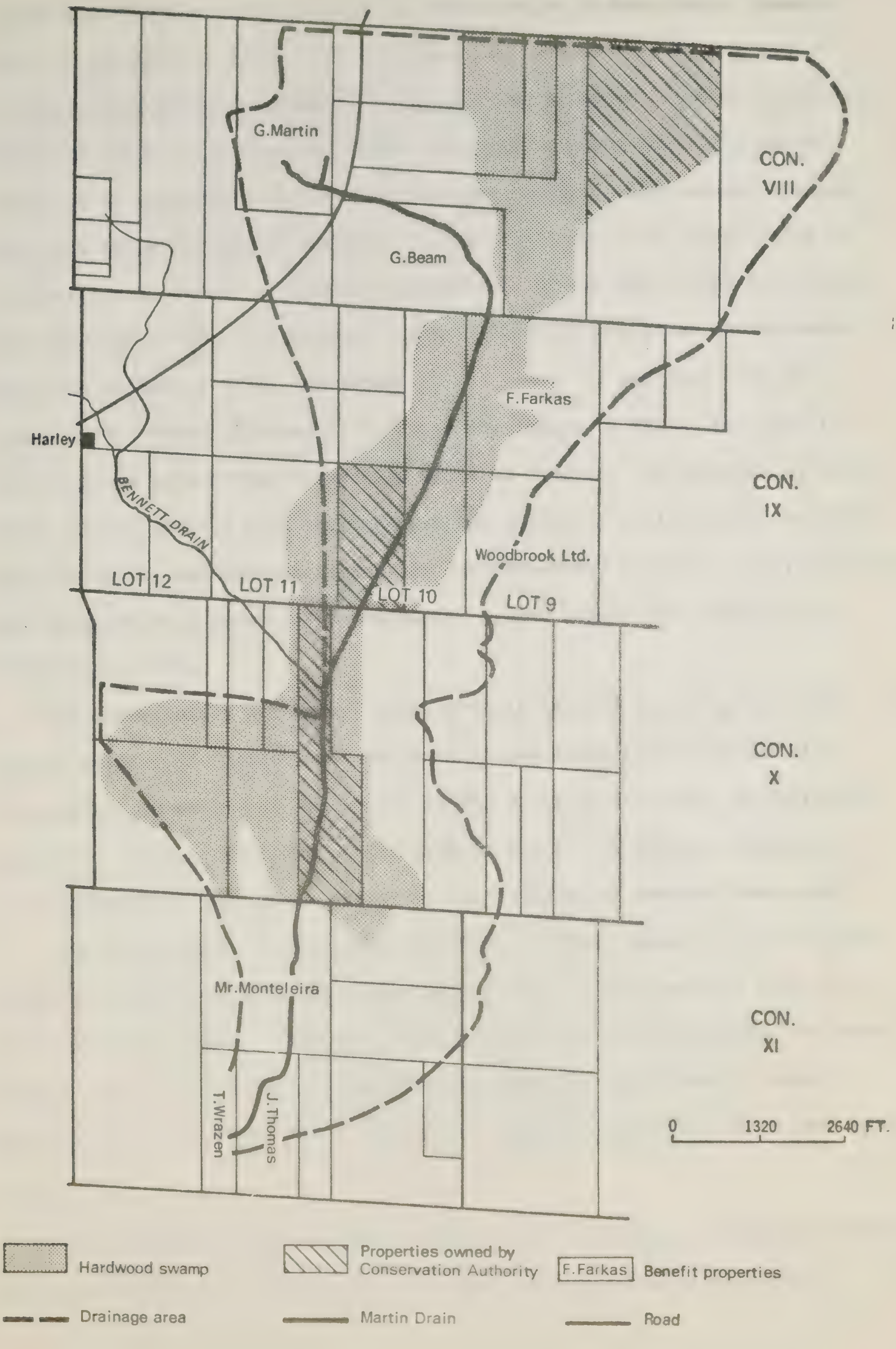
The Martin Drain is located in Burford Township, Brant County (Fig. 4.1) and was constructed in 1969. The drain extends for a distance of approximately six miles and includes 1,850 acres within its drainage area. Approximately 60 percent of the drain length is located in hardwood swamps. A petition to construct this drain was initiated in 1968 by three landowners in Lots 9, 10 and 11 in Concessions 8 and 9. (Fig. 7.3).

The outlet for the drainage waters from this area is a watercourse which drains to the south through woodland, part of which is owned by the Long Point Conservation Authority. This watercourse apparently was an existing municipal drain (Harley - McCormack), but had not been maintained for more than 40 years so that at the time of the petition there was little evidence of a defined watercourse, and the woodland was in a swamp condition.

The woodland owned by the Conservation Authority was purchased in order to preserve a natural water storage area and for multiple-purpose forestry. These properties are currently managed under agreement by the Forestry Branch of the Ministry of Natural Resources.

The Conservation Authority, concerned that the installation of a drain would adversely affect the woodland, made an examination of their property in 1969. This unpublished report provides some evidence of the characteristics

Figure 7.3 The Martin Drain, Burford Township, Brant County



of the Conservation property prior to construction of the drain. Squeeze tests of the surface layers of the muck soils produced water in a number of areas, indicating the presence of a high water table. In some locations there was evidence of standing water during late spring and early summer. The level of watertable as indicated by study wells varied between two and five feet below the ground surface. It was concluded that construction of the drain would result in a drop in watertable of one and a half feet below the pre-drain level. The maximum lateral effect of the drain on the watertable was estimated to be approximately 200 feet. It was felt that this change in the watertable would not cause any injury to trees, but that the water-holding role of the properties would be damaged. As a result of this report it was obvious that the Conservation Authority would derive no benefit from the drain, and the assessment for benefit levied against these properties was cancelled as a result of a successful appeal before the County Court in November, 1969.

The Conservation Authority, despite their initial survey of the area did not monitor the effects of the drain on the swamp after construction. The present assessment of the impact of the drain on this area is therefore based on a visual inspection of the area by two of the authors accompanied by foresters from the Simcoe Office of the Ministry of Natural Resources.

The construction of the drain resulted in direct damage to the woodland caused by clearance along the drain right-of-way of an unusually wide strip of 130 feet of timber. Moreover, over part of this area the drain contractor cleared the trees before the Conservation Authority could itself harvest the timber. Saw logs up to 20 inches in diameter were bulldozed to one side.*

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*A letter protesting this clearance written by Mr. Halpenny (District Forester, Hespeler Office) is on file with the Long Point Conservation Authority.

It should be noted that the salvaging of wood under these conditions only produces about ten percent of the value derived from cutting the standing timber.

Visual inspection of the woodland, which consists of silver maple, cottonwood, black willow and some ash, revealed no obvious damage to trees near the drain as a result of lowering the watertable. Silting had occurred and the drain in places is now only two and a half to three feet in depth instead of the original depth of four and a half feet. Fifty yards from the drain the watertable was encountered at approximately two feet below the surface.

Interviews with landowners near the drain produced little evidence of serious effects on the environment. Areas of privately-owned woodland adjacent to the Conservation Authority land were drier after installation of the drain. Two landowners indicated that their irrigation ponds in the vicinity of the drain experienced a fall of water level of four or five feet after dredging of the drain.

The installation of the drain has probably reduced the importance of the woodland as a water storage area in spring. The use of the area for forestry does not appear to have been damaged by the small drop in watertable. The drain may have produced some small beneficial effects in the woodland. The cleared strip along the drain is now heavily overgrown with silver maple and balsam poplar saplings and forms an attractive area for wildlife. It is also possible that the somewhat drier soil conditions will encourage the colonization of the woodland by more commercially valuable trees such as the sugar maple.

A survey of a sample of farms along the Martin Drain, identical to the surveys undertaken in the sample townships, revealed that construction

of the drain has been a significant benefit to local agriculture (Table 7.1). Improvement of pasture grasses, increased yields, and some switches to more productive crops have enabled farmers to raise more beef and dairy cattle. Benefit-cost ratios for the project (procedures for calculation described in section 5.2) are as follows:

	Life of Drain		
	5 years	12 years	20 years
6% interest rate	1.31	2.61	3.57
8% interest rate	1.24	2.35	3.06
10% interest rate	1.18	2.12	2.65

It would appear that the drainage project has been a clear success from the standpoint of agricultural production, detrimental in that the wetland's capacity as a reservoir has been reduced, and not particularly harmful or helpful to the trees in the woodland.

8th LINE MUNICIPAL DRAIN

The 8th Line Municipal Drain is located in Innisfil Township, Simcoe County, and was constructed in 1969 (Fig. 4.1). The drain involves the channelization of a portion of Lover's Creek which extends through the middle of the Stroud Swamp. Approximately 5,200 acres are included within the drainage area, of which 1,600 acres are in forested swamp. (Fig. 7.4). A petition to construct the drain was initiated principally by a landowner wishing to eliminate flooding on 100 acres of agricultural land adjacent to the north end of the swamp.

Prior to the construction of the drain, approximately 200 acres of land in the centre of the swamp on either side of County Road No. 21 were flooded

Figure 7.4 The 8th Line Municipal Drain, Innisfil Township, Simcoe County

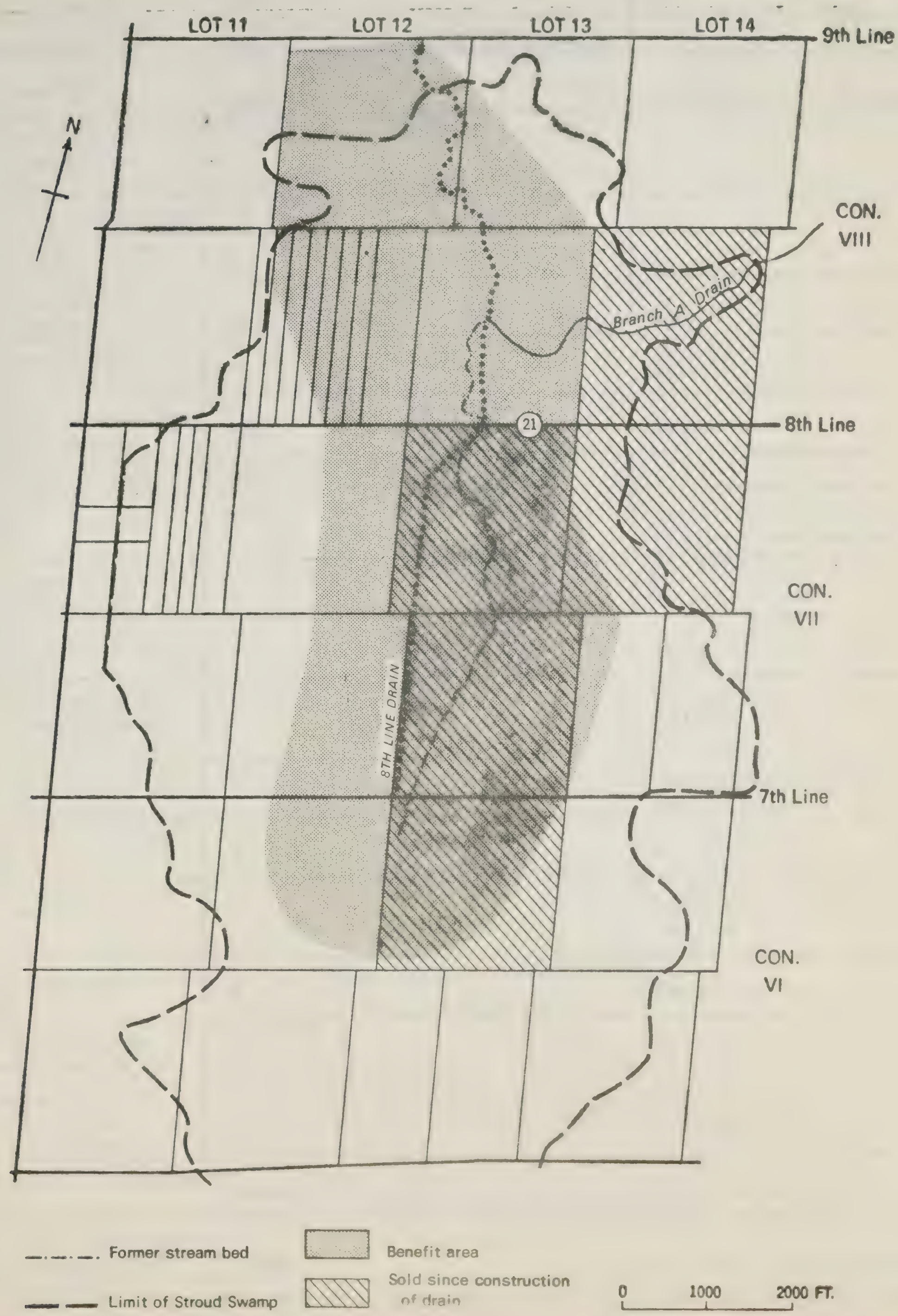

Table 7.1 Pg. 183

	STROUD DRAIN	MARTIN DRAIN
Soil conditions	muck and silty clay loam (Simcoe Series)	Sand and muck
Total no. of properties	49	33
No. of farmers interviewed	9 (incl. most of the properties with benefit assess.)	9 (includes most of the prop. with benefit assess.)
Type of drain project	new drain	dredging old channel
No. of sample properties with field underdrainage prior to project	2	2
No. of sample properties with field underdrainage installation since project	0	1
No. of acres with new field underdrainage	0	76
Total cost of new field underdrainage	0	$3000
Farmer's estimate of no. of acres affected by drain	535	413
No. of acres assessed benefit	95	333
Land-use change	none	some improvement of pasture and switch to grain
No. of farmers reporting increased yields	0	5
Market value of increased crop production	0	$2600
Average annual increase in cost of inputs due to drain (incl. field underdrainage)	0	$5,700
Types of input changes besides field underdrainage	0	purchase more beef and cattle
Average no. of days earlier seeding possible	0	3
Changes in livestock	0	More beef and dairy cattle
Changes in gross income from livestock	0	$12,675
Increase in income due to change in feed sales or purchases	0	+$340
Net annual increase in farm income (calculated)	0	$6,975
Farmer's estimate of increase in income (mode)	none	(1) (1 - 5)%
Farmer's estimate of no. of years requ'd for drain to pay for itself (mode)	never	(never) (2 - 5yrs.)
Total cost of drain for sample properties	$7,290	$22,412

because of a number of beaver dams. The major portion of the swamp was forested, the main species being white cedar and trembling aspen with small amounts of birch, balsam fir, willow and black ash. The swamp provided an ideal area for ducks and marsh birds. In autumn 200-300 ducks used the swamp as a resting area during migration.* Deer and a variety of other game animals, as well as furbearers such as beaver and muskrat, also inhabited the area.

Approximately 25-30 people hunted duck and deer in the swamp each year. Despite the hunting the swamp provided good protection for waterfowl and deer, because the flooding prevented easy access to large portions of the swamp. There was also some trapping of beaver and muskrat in the swamp.

The construction of the drain resulted in the elimination of the flooded areas of the swamp, thus largely destroying the value of the area for waterfowl and marsh birds. Drainage has probably also reduced the value of the swamp as a water storage area, and may have increased flood peaks further downstream on Lover's Creek. Unfortunately no discharge record is available for this stream.

The beaver have disappeared from the swamp and drainage has also adversely affected other furbearers. According to local landowners deer are still present in the area, but the swamp now provides less protection because drainage has increased the accessibility of the land to hunters. The importance of the area for recreational hunting has declined with the disappearance of the ducks, although there is still some deer hunting. Interviews with landowners indicate that trapping of furbearers no long occurs

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*Personal communication provided by Dr. F. Gilbert, Department of Zoology, University of Guelph.

in the swamp.

The adverse effects of drainage on wildlife and hunting have been substantial in the four years since drain construction, and are about to become even more serious as a result of recent sales of substantial areas of land to holding companies who are in turn offering the land for sale in 10 to 25-acre lots for marketing gardening. Already small acreages of land adjacent to County Road No. 21 have been cleared of vegetation, and eventually at least 500 acres of swamp timber may be cleared eliminating the wetland as a wildlife habitat.

The majority of landowners within the benefit area of the drain have not gained any agricultural benefits. In fact, none of the sample farms in the agricultural survey have, as yet, undergone any increases in production (Table 7.1). The land at present still remains wooded and has not been converted by the original owners to agricultural use. However the construction of the drain does appear to have acted as an incentive for speculators to buy the land from the original owners. Holding companies now own a considerable acreage of the Stroud Swamp and are offering more than 500 acres of land for sale.

The following advertisement appeared in the Toronto Star on Wednesday, August 15th 1973.

GARDENING LAND

> 10-20 acre parcels from \$17,500 - \$19,500 each. Valuable fertile black soil similar to the Holland Marsh. Located S. of Barrie close to Hwy. 400, excellent investment, completely severed.

A field examination of these areas which are for sale raises some doubts concerning their excellence for market gardening. Inspection of the banks of the drain indicate that the depth of black muck soil varies widely

from less than one foot to approximately three and a half feet. At least one of the areas adjacent to County Road No. 21 from which the vegetation has been bulldozed has only 12 to 15 inches of black soil underlain by silty clay loam. Observations in Simcoe County indicate that a lowering of the surface elevation by six to ten inches occurs in removing the forest cover and in the initial soil loss of the first two to three years of cultivation. It is generally felt that muck soil depth must exceed four feet before the land can be regarded as having a good capability for agriculture. (Leeson, 1969).

Clearly, the environmental damage to the Stroud Swamp has been considerable due to the construction of the drain. Further, little agricultural benefit has occurred, and there is some question as to whether or not the agricultural benefits will ever materialize. The one clear "benefit" of the project may have been to make the land attractive to land speculation and, eventually, to other buyers, probably from urban areas.

7.3 Urban-Rural Drainage Conflicts

Conflicts between owners of agricultural and other rural land and owners of urban land have been referred to in many parts of the Province. Yet, as with conflicts between agriculturalists and conservationists, well documented cases are difficult to find; and one is led to suspect that such conflicts may be either very infrequent or rather unimportant. To investigate the problem the researchers undertook three studies: (1) an analysis of the briefs submitted to the Select Committee on Land Drainage and of the hearings conducted by the committee; (2) a survey of a sample of "urban" properties along the drains selected for detailed analysis in the seven townships; and (3) an investigation of an alleged urban-rural conflict on the periphery of

the City of Niagara Falls.

(a) analysis of rural-urban conflicts described in the Briefs and Hearings of the Select Committee

Rural-urban conflicts are mentioned many times in the briefs and the summaries of the Committee hearings. Nevertheless, cogent descriptions of specific cases are most rare. One encounters many references to the "urban problem" or to the problem of "urban shadow," but is left wanting for a real understanding of what the problem is. However, by piecing together comments from a number of briefs or hearings, many of which overlap in their concern for a particular case, eight major categories of problems can be identified.

(1) urban-rural cost sharing

When an agricultural drain passes entirely through farmland, particularly when all farmers derive direct benefit from the drain, the problem of determining how the costs of the drain are to be shared is minimized. But when the drain passes through a residential, commercial, or industrial area, (e.g., to permit connection with an outlet downstream), and is seen as providing no benefit to the surrounding urban properties, the urban owners may resent having to pay an "unfair" portion of the construction costs (e.g., Sarnia hearing, Jan. 9, 1973). This problem appears to become serious if urban owners are aware that they are paying more than a minimal or token cost. Not only urban landowners are dissatisfied in this kind of situation, however. In some cases decisions have been made to construct more costly drains through urban areas than through the main agricultural area that is deriving benefit. For example, closed drains may be required for urban areas while open ditches suffice elsewhere. Under these circumstances farmers have complained because their assessments have been high in order

to subsidize costly construction to satisfy "urban demands." Clearly, no smooth-functioning mechanism for determining rural-urban cost sharing is in practice.

(2) physical damage to agricultural drain in urban areas

Some reference in the hearings and briefs is made to physical damage which occurs to agricultural drains when they pass through urban areas (e.g., brief by Likerr). The view is expressed that the urban population does not understand the function of the drains, nor of the need to keep them clear of garbage and other fill. In one recreation area urban cottage owners are reported to have blocked a drain's outlet to the lake, apparently without realizing the effect on the drain's functioning (hearing in Cayuga, July 23, 1973).

(3) the effect of land speculation on drain construction

Many references are made to the detrimental effects of land speculation on the construction and maintenance of agricultural drains. It is argued that land speculators, who own significant acreages in the urbanizing portions of Ontario, have no real long-term interest in agriculture, and have no interest, therefore, in applying for drainage grants. This can have the effect of stopping genuine farmers in the region from getting drains constructed or maintained. One case is sited where farmers could not qualify for an A.R.D.A. drainage grant because the A.R.D.A. officials felt that an insufficient quantity of "genuine" agricultural land would benefit (hearing in Cornwall, Aug. 29, 1972).

(4) the effect of "ribbon" settlement patterns on drain construction

A common form of "urban" settlement in Ontario is the string-like distribution of houses along rural roads, normally referred to as "ribbon" development. Although controls under the Planning Act have deterred this

form of settlement in recent years, it is common surrounding almost every city, town, and village in the Province. Ribbon development potentially gives rise to two problems concerning agricultural drains. One is the possible tendency for non-farmers to physically abuse drains in which they have no interest. The other relates to the instigation of procedures to undertake drain construction. Some have argued that, with the emphasis in the Drainage Act on the number of property owners rather than the acreage they own, a majority of "urban" landowners with small (e.g., 1-acre) lots can stop farmers who own the overwhelming portion of the land from petitioning for drain construction with a subsidy (hearing in Cayuga, July 23, 1973). This conflict in interest is seen as a serious threat to genuine farmers, who appear to be in an "unfair" position.

(5) pollution of wells by agricultural drains

It has been reported (e.g., brief by Mrs. M. Sol) that agricultural drains have caused urban well water to become polluted. Presumably, the drain water, "polluted" by runoff from fields, has infiltrated the ground water which supplies wells. The researchers have found no firm evidence supporting this claim, and can neither confirm nor reject it.

(6) pollution of drain water by urban land users

A fairly common report in the briefs and hearings concerns the pollution of drain water from urban sources, particularly septic tanks (e.g., hearing at Sarnia, Jan. 9, 1973). It has been noted that the water in drains which passes through residential or industrial areas can be observed to be polluted. The implication is that, without the drains to spread the pollutants, the problem would not arise. The researchers have not observed this problem first hand, but recognize that it does arise. A recent study published by the Ministry of the Environment documents the problems in the

Township of Sandwich South (1972).

(7) improper hookups to drains

Closely related to the last-mentioned problem is that concerning illegal hookups to drains. Problems have arisen where urban landowners have permitted water, either storm runoff or septic systems, to flow directly into drains (e.g., brief by Kent Co. Soil and Crop Imp. Assoc.). This can result not only in water pollution but also the overloading of drain channels. When overloading occurs the drain can not function properly, and water backs up in fields.

A special case of improper hookups occurs when urban areas as a whole (e.g., a municipal government) wish to use agricultural drainage channels as an outlet for storm runoff. Even when the urban area is prepared to modify the channel to carry the increased load, problems can arise if rural residents see this action as a threat to the "natural" status of the rural landscape. The researchers examined such a case near the city of Niagara Falls, which is described later in the chapter.

(8) rural-urban sociological problems

The researchers have concluded that many of the urban-conflict problems referred to in the briefs and hearings have a basis in fact, but that they also tend to be exaggerated or over-simplified by a lack of understanding by all parties concerned. It appears to be too easy for farmers to blame urban areas for having little concern for agricultural interests, and it is obvious that many urbanites have little understanding of the function of agricultural drains. Both urban and rural groups appear to develop unfair biases about the other, and tend to generalize rather intricate problems under the standard heading of "urban" or "rural." One sometimes gets the impression that "urban" problem really means a problem

with urban people, and that, in turn, town dwellers see agricultural drains as nuisances created by farmers. Perhaps the situation is inevitable, but it can have the undesirable effects of clouding real issues and of deterring progress in the fair solution of important controversies.

(b) Analysis of Conflicts in Urban Portions of Sample Townships

The seven townships and sample drains selected for detailed study were chosen to allow a good opportunity for rural urban conflicts to be uncovered. Care was taken to include growing towns and drains adjacent to those towns. Yet very few drains studied had "urban" properties assessed part of the project cost, and no drain appeared to inspire any particular response--good or bad--from an urban area.

The "urban" properties encountered in the drain analysis were usually "ribbon"-type properties strung along rural roads. They ranged in size from one-quarter to 10 acres. As indicated in Section 4.4, 10 percent of all such properties, which tended to outnumber by far the farm properties along drains, were studied.

The situations examined by the researchers failed to uncover any of the problem situations mentioned in the briefs or hearings of the Drainage Committee. Many of the urban landowners were unaware that they were located near a drain, and they seemed unaware that they had been assessed outlet costs. None reported any inconvenience or benefit caused by the drain. No farmers interviewed indicated any problem emmanating from the urban landowners. One can only conclude that, for those areas selected for detailed study, rural-urban interests appeared to be entirely compatible.

Since the urban landowners were assessed such a small portion of the construction costs (usually only a few dollars) they were either unaware of or completely satisfied with the drain and the cost-sharing mechanism. Just

as for farmers who derived no benefits from drain construction, the urban landowners who were aware of the situation appeared to accept their share of the collective responsibility of assisting those who wished to see drain construction go ahead.

(c) Analysis of Land-Use Conflicts on the Outskirts of the City of Niagara Falls

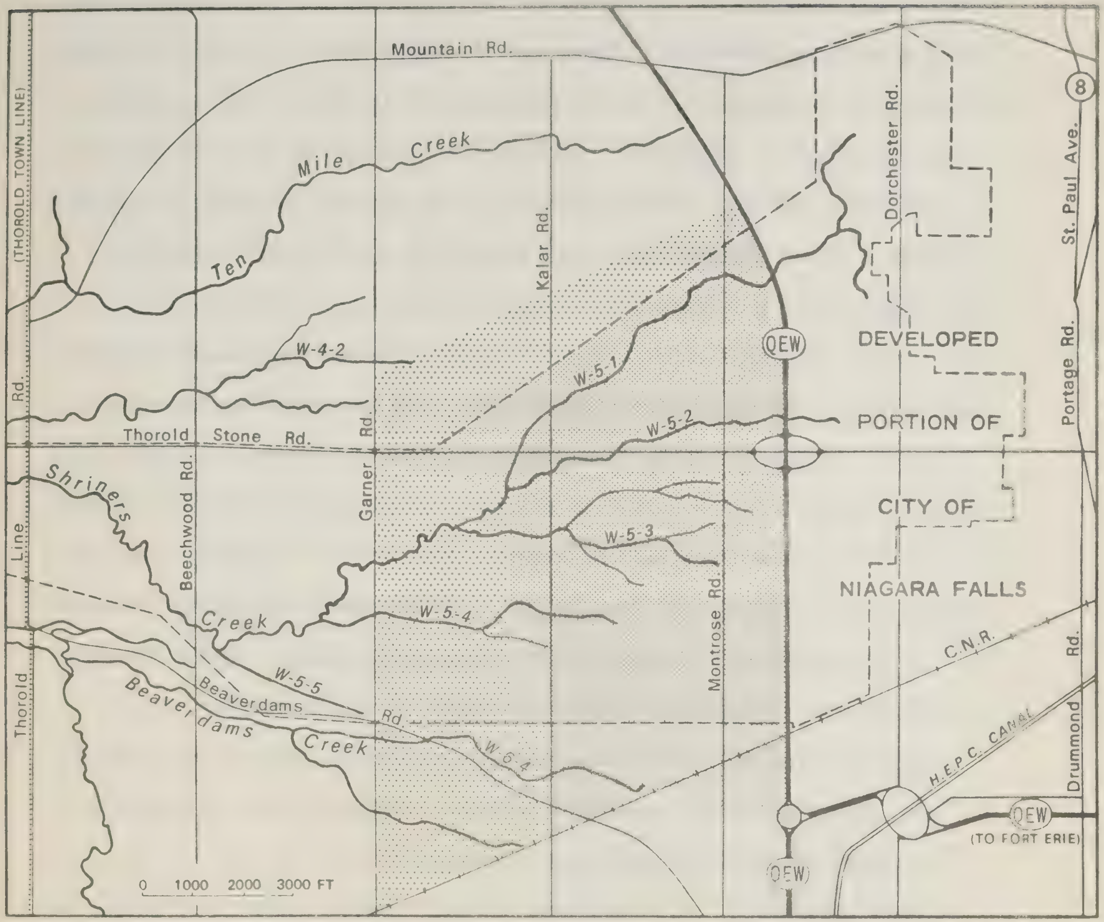
At the request of the Select Committee the researchers undertook a detailed investigation of alleged conflicts along the rural-urban fringe of the City of Niagara Falls. The conflict was brought to the attention of the Select Committee at a hearing in St. Catherines on July 16, 1973 (8:00 p.m.) (see transcript of meeting, pp. 105-139). Persons appearing before the committee expressed the strong feeling that stream channelization undertaken by the City of Niagara Falls was detrimental to farm operations and the environment.

Several days in the Niagara district were required to gain a detailed understanding of the conflict situation and of the sequence of events surrounding it.

Following is an account of the history of the conflict as interpreted by the researchers. The sequence of occurences is interesting, as it may be one of the clearest examples of a genuine rural-urban conflict. The authors will make no value judgements regarding blame in this conflict, as the matter will continue to be before the courts, and since vital data, particularly regarding stream flows and environmental impacts, are unavailable.

The area of concern coincides roughly with the watershed of Shriners Creek, which flows westwards through the City of Niagara Falls towards the Welland Canal (Fig. 7.5). Currently Shriners Creek and its tributaries comprise a drainage area of about 1,935 acres, limited on the north by the

Figure 7.5 Western Outskirts of the City of Niagara Falls



Boundary of Shriners Creek Drainage Area

Area Planned for Development Within Next 25 Years

Area Planned for Development Beyond Next 25 Years

Ten Mile Creek watershed and on the south by the watershed of the Beaverdams Creek system. The eastern boundary is approximately the Queen Elizabeth Highway (QEW), and the western limit approximates the western boundary of the City of Niagara Falls (Thorold Town Line). According to current plans an area east of the QEW will be included within the watershed following the extension of storm sewers into the various tributaries of Shriners Creek. This would increase the size of the watershed from 1,935 to 2,807 acres.

In June, 1968 the City of Niagara Falls commissioned R. V. Anderson and Associates Ltd., Consulting Engineers, to report on flood control and pollution abatement within the City of Niagara Falls Municipal Area. The time span to be considered was 37 years, with recommendations made to the year 2005. The report recommended improvement of approximately 37,600 feet of streambed along several branches of Shriners Creek to facilitate storm sewer relief. It was also recommended that north-south collectors be attached to the main channels, and that channel improvement specifications allow for future intensive residential and industrial development.

At the time of the R. V. Anderson Report, the City of Niagara Falls had intended to limit development to the east of the QEW until all land in the area had been developed. However, rising land costs within the area led the City in 1973 to adopt the North-West Residential District Secondary Plan, which allowed for the development of 1,170 acres west of the QEW. (Official Plan Amendment No. 43). Most of the land to be developed over the next 25-year period (996 acres) will be within the Shriners Creek drainage area. The total North-West area which will be eventually developed comprises approximately 2,000 acres, of which 298 acres in addition to the 996 is within the Shriners Creek watershed. When the entire North-West area is developed only 23 percent of the watershed

will remain as "rural" land.

Following the recommendations of the R. V. Anderson Report, watercourse improvement on the W-5-1 branch of Shriners Creek was initiated in September, 1969. Under Section 377, Subsection 15 of the Municipal Act, land was acquired to facilitate channelization between Kalar Road and the QEW. Land acquisition, widening and deepening actually began in September, 1971. In December, 1972, a bylaw was passed for the deepening and improvement of portions of two additional tributaries of Shriners Creek:

(1) W-5-2 tributary from Kalar Road westerly approximately 1,000 feet;

(2) W-5-3 tributary from Kalar Road westerly approximately 1,800 feet.

The W-5-4 tributary is to be deepened and improved west of Kalar Road (1,300 feet) by the developer of Ascot Woods Subdivision. Under agreement the developer is required to improve the stream and deed the necessary 100-foot right-of-way over to the city, free of cost. Watercourse tributary W-5-5 will not require improvements in the foreseeable future.

The above channelizations and expropriations (100-foot rights-of-way on all channels) are deemed necessary by the City of Niagara Falls to attain the following objectives:

(1) to provide for a sufficiently deep outlet for badly needed storm sewers east of the QEW, and to alleviate basement flooding;

(2) to develop vacant lands east of the QEW in accordance with the Official Plan;

(3) to curb rising local real estate costs by allowing residential development in rural areas west of the QEW (North-West Residential District Secondary Plan);

(4) to prevent overloading of the Niagara Falls pollution control plant because of continued storm and sanitary sewage from newly

developed land;

(5) to avert prohibitive costs in running storm sewers uphill to the Niagara pollution plant;

(6) to expropriate 100-foot rights-of-way along entire water course so that

a) if any erosion problems occur, they will be under the sole jurisdiction of the Municipality;

b) by acquisition of land downstream from development, any threat of legal claim would be eliminated; i.e., flooding and remedial measures can be taken where necessary;

c) by expropriating under the Municipal Act, farmers will not be taxed on land that can not be farmed. Since the channel improvements are for urban areas, the costs are assessed against the Urban Service Area and not against the local farmers;

d) land can be set aside for the creation of a small man-made lake in the upstream area. The lake could be used for possible flood control downstream (the city has purchased 40 acres of land on Shriners Creek at Garner Rd. for this purpose).

The land expropriation and channelization procedures have prompted a considerable response from rural dwellers within the Shriners Creek watershed who are opposed to the projects. A major group opposing the action, the Committee of a Thousand, was created in 1968 to aid residents in the Niagara region in their fight against conflicts which threatened rural land, particularly to advise various groups on procedures for attacking environmental problems. The Committee of a Thousand, whose membership peaked at about 700, currently has 20-25 "hard-core" members. The Committee has advised local residents on procedural methods involved in opposing the Shriners Creek improvement scheme, and has encouraged the formation of the Shriners Creek Rural Area Preservation Group (SCRAP).

SCRAP, headed by a local farmer, has a membership of approximately

eighteen local landowners, all opposed to the channelization scheme. Early in 1973 the group applied for an interim injunction against the project which would enable residents to discuss the matter with City representatives. The plaintiff's claims were for:

(1) an injunction to restrain the City of Niagara Falls from interfering with the physical and biological characteristics of Shriners Creek and its tributaries; and

(2) a mandatory injunction requiring the City of Niagara Falls to preserve and replace previously existing natural environmental characteristics of the area--i.e., flora and fauna--where disturbed.

The Supreme Court of Ontario turned down the injunction on the grounds that the case lacked professional advice regarding effects on the natural environment. It felt that proof of damages could not be substantiated.

Currently, SCRAP is compiling data for a case against the City of Niagara Falls with respect to the W-5-2 and W-5-3 watercourse improvements on Shriners Creek as well as other creeks in the area (Beaverdams Creek W-6-4 and Ten Mile Creek). SCRAP'S specific concerns are:

(1) the effects of additional water on fish spawning grounds in downstream areas;

(2) the effects on the Muir Wildlife Sanctuary at the junction of the W-5-5 watercourse and the main branch of Shriners Creek (shown as a biologically sensitive area in the Niagara-Lake Erie Transportation Study);

(3) the effects of channelization on areas designated as "hazard lands" in the Niagara Peninsula Conservation Report, Vol. 2, 1972; and

(4) the effects on the natural environment within the vicinity of the various streams.

Finally, farmers in the area are also concerned about the expropriation of land along tributaries which pass through their properties. Although several expropriations will not be carried out for some time, the effect will be to divide farm properties into "unmanageable units." An example cited is the channelization of the W-5-5 and W-6-4 watercourses, which will leave a strip 250 feet wide to be farmed.

Clearly, the Shriners Creek drainage project has given rise to a rural-urban land-use conflict. Since the project was initiated under the Municipal Act, the general procedures under the Drainage Act do not apply and are not in question. But the rural residents feel that the Drainage Act should somehow be involved, which reflects the feeling that the two Acts can be seen to overlap along the rural-urban fringe. Lack of knowledge on the part of SCRAP as to the legal procedures under the two Acts has contributed to their frustration. Furthermore, although legal notices of the scheme were publicized in local newspapers beginning in December, 1969, it was not until December, 1972 that the rural residents became aware of it. The feeling that the legal notices were insufficient has increased the rural-urban split, and reconfirmed the farmer's belief that the City does not care about them or their land.

Channelization was initiated because of recommendations in the R. V. Anderson Report, a highly technical engineering report which did not consider the full environmental consequences of the project. The Niagara Peninsula Conservation Authority supports the scheme, although the researchers are unaware of any studies undertaken to support or refute the claims concerning negative impacts on the natural environment. The City of Niagara Falls has ruled out the possibility of alternative storm sewer projects, although it would be useful if alternatives, together with economic and ecological costs, were examined.

Finally, it is apparent to the authors that communication between the rural and urban groups is seriously impeded at this time. Both groups claim to be willing to discuss the matter with the other, but suspicion and disrespect seem to have prevented this from occurring.

7.4 Conclusions

Aside from the detailed conclusions identified within Sections 7.2 and 7.3, four general conclusions concerning land-use conflicts are apparent:

(1) Although land-use conflicts of the wetlands and urban-rural types can be documented and are of real concern to responsible citizens, the findings of this study suggest that genuine conflict situations are rather rare. In the vast majority of cases the construction of recent agricultural drains has lead to no serious conflicts in land use.

(2) Although problems of competing land use in the urban fringe and in wetlands have been singled out for study, it should be noted that drainage projects which affect permanent streams constitute a further category of drains which involve land-use conflicts and problems of public versus private interests. A number of cases of conflicts arising from the adverse effects of drains on sports fisheries have been recorded in recent years in Ontario, particularly in Norfolk, Grey and Bruce Counties.

(3) In areas of genuine land-use conflict current procedures for obtaining approval for drain construction have not been adequate to deal with the problems of potential conflict. This applies primarily to the Drainage Act but also to other Acts (e.g., the Municipal Act) that have some concern with drains in conflict areas.

(4) A number of schemes alternative to current practices can be envisaged which might be able to assist in the resolving of potential land-

use conflicts. Four primary possibilities are presented here, while fuller legal implications are analysed in Chapter 8.

(i) Full Benefit-Cost Analysis Prior to Drain Construction

Benefit-cost analysis can provide a logical framework for the evaluation of a course of action, and it has been used extensively in the resource management field. The general procedure is to place a precise quantitative economic value on all benefits and costs associated with a project, and to make decisions concerning the advisability of the project on the basis of the values of the benefit-cost ratios. The researchers envisage severe problems, however, for the use of this technique in Ontario except, possibly, for drainage schemes much larger than the norm or for special rural-urban drains. Firstly, many of the values associated with environmental impacts (e.g., in wetlands) are intangible and cannot be measured readily in monetary terms. Some procedures are available for attaching quantitative values to the recreational role of wetlands (Goldstein 1971, Barstow, 1971), but this only measures the value of one of the many functions of a wetland. No practical means are currently available for measuring the economic value of the hydrologic, pollution-filter, aesthetic or other functions. If a very large project were being considered, similar, for example, to the large-scale U.S. projects where benefit-cost analysis has been used with some success, it would probably be advisable to attempt to apply the method. But drainage schemes in Ontario are small in scale, and the large amount of research necessary to attempt a full benefit-cost analysis prior to drain construction would, in all likelihood, not be feasible. If a drain were being considered where rural-urban conflicts were likely without the added complication of "environmental" conflicts, it might be possible to

assign economic benefits and costs rather easily to alternative proposals. Many of the urban-related conflicts reported in Section 7.3, however, contain too many intangibles for this approach.

(ii) Land Use Planning

A number of briefs presented to the Select Committee on Land Drainage suggest that problems of competing land uses where environmental impacts are involved could be resolved by zoning the landscape into various categories.

Category 1 Areas where drainage should be facilitated because of high agricultural benefits and a minimum of land-use conflicts.

Category 2 Areas where drainage should be prohibited because of the likelihood of environmental damage.

Category 3 Areas where the situation is less clear-cut and considerable study would be required on each project before drainage could be allowed to proceed.

In some cases the type of land-use planning advocated appears to involve zoning at a macro-scale. For example, category 1 would include most productive agricultural areas in the province. A second school of thought suggests the use of the three types of category at a micro-scale involving the mapping of small drainage basins which could ultimately be fitted together to form a master plan for an entire major watershed. The results of this study of land drainage in Ontario suggest that land-use zoning at a macro-scale would not be particularly helpful in resolving conflicts. The wide variation in the extent of agricultural benefits at the individual drain level, even within a single township, indicates that it is unrealistic to indentify

large regions of the province in which drainage should be facilitated because of its agricultural benefits. The prohibition of drainage in certain parts of Eastern Ontario would certainly prevent the construction of some drains which produce considerable agricultural benefits. Conversely, the automatic approval of all projects in Southwestern Ontario might result in the disappearance of the last remnants of wetland which, by virtue of their very scarcity, may be regarded as of major ecological importance. The much more detailed land-use zoning involved in the micro-scale drainage basin approach appears to be more realistic in terms of judging the advisability of land drainage projects. However, the amount of work necessary to evolve detailed zoning of this type appears to be considerable and may only be justified in areas of intensive land drainage activity.

(iii) A Regional Drainage Committee

It is possible that many cases of competing land use might be resolved if greater consultation took place between various interest groups during the planning stages of a drainage project.

A partial model for this type of consultation is already in existence and has operated with some success for at least the past year in relation to decisions on ARDA grants to drainage projects. Rural development councillors, who are responsible for decisions on the payment of ARDA grants in areas where agricultural drainage is eligible for such grants, have been instructed to ensure that each drainage project is in accord with the wishes of other resource management departments. No specific guidelines have been set up, but the existing practice appears to usually involve consultation with the local Conservation Authority and the District Office of the Ministry of Natural Resources.

It might be appropriate to consider the organization of regional committees consisting of representatives of agriculture, Ministry of Natural Resources, the relevant Conservation Authority, and urban interests to review land drainage proposals. This committee might inspect the land involved after a petition is received by the township council or when an urban area anticipates drain construction which will affect rural areas and before an engineer is appointed. This initial inspection might reveal that the drain would not produce any agricultural benefits or would cause serious environmental impacts. The council and the petitioners of the drain could then consider these factors before any money is spent on an engineer's report. In the case of the 8th line municipal drain through the Stroud Swamp such an initial report might have resulted in the termination of the project.

Further consultation with this committee could take place after an engineer's report is received. The report could be circulated to the committee, and consultation with the engineer and township (or city) council might be required in some cases in order to minimize environmental problems or to satisfy competing land uses. There is considerable evidence from a number of drainage projects in Ontario that this type of consultation, which is usually absent at present, might significantly reduce conflicts of interest. There appear to be many instances where adjustments in the design of the drain would remove adverse environmental impacts without reducing agricultural benefits. A good example of this circumstance is the Pritchard Drain in Malahide Township, Elgin County, which the engineer originally planned to construct through the Calton Swamp, an important wildlife area at the head of the watershed (Pell, 1972). This swamp was not affecting agricultural drainage, and there is no evidence

that stopping the drain short of the swamp has affected the agricultural benefits.

It is possible in the case of the Martin Drain reviewed earlier in this chapter, that consultation between an engineer and a committee might have resulted in less damage to the water-holding role of the woodland swamp. It might have been possible to construct the drain for only a small distance into the woodland, simply utilizing the swampy nature of the area to accomodate the water from the agricultural land. This procedure might produce somewhat higher spring water levels in the swamp but probably would not injure the timber. The possibility of utilizing swamps in this manner has also been suggested by representatives of the Ministry of Natural Resources in Eastern Ontario, where some drains extend considerable distances through woodland swamps to provide outlet for small areas of agricultural land. There are problems involved in this suggestion. Engineers consulted pointed out that a lack of sufficient gradient sometimes necessitates extension of the drain, and that there is a danger of injury to property adjacent to the swamps if adequate outlet is not provided. However, the institution of dialogues between the engineer and environmental experts at least opens up the possibility that drains can be designed to minimize environmental damage as well as creating the desired agricultural benefits.

In the case of conflicts on the outskirts of Niagara Falls, it has already been pointed out that lack of communication has been a serious impediment to the solution of problems. A committee which involved environmental experts might easily have foreseen the problems curently arising, and could have forced the engineer and the City to consider landscape impacts and, perhaps, alternative proposals.

(iv) Formulation of Land-Use Priorities

One of the severe problems evident in almost all cases of conflict is the lack of clearly-defined land-use priorities at the local or provincial levels. With respect to wetlands, for example, no guidelines have been formulated indicating the general amounts of wetland which should be preserved for hydrological, recreational or aesthetic purposes. Not all wetland needs to be preserved, neither should it all be destroyed. The determination of wetland needs for hydrological purposes requires considerable scientific research. The needs for recreation and aesthetic purposes presumably also require extensive surveys of current and potential users. Yet certain general guidelines could be determined now which could be useful for those charged with resolving conflict situations. For example, it might be determined that a limit should be placed on the reduction in wetland within broad regions to ensure that a minimum of wetland would continue to be available. Obviously, general guidelines such as this would be most effective if determined through the joint cooperation of a number of concerned governmental and other agencies. But the task of formulating general rural land-use policy is not insurmountable, and it should be of great assistance in the resolution of conflict situations.

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Chapter 8

ALTERNATIVES FOR FUTURE LAND DRAINAGE LEGISLATION

8.1 Introduction

This investigation has confirmed that a number of genuine problems have arisen with respect to land drainage in the rural portions of Ontario. At the same time it has shown that the scale of these problems seldom appears to be large, and that there is no gigantic crisis demanding radical action. The major problems, described in detail in preceding chapters, concern agriculture, the "environment," and urban-rural interfaces. The primary agricultural problem is that drains are sometimes constructed which have not led to enough benefits to pay their way (even after government subsidies). As for the environment, the study has shown instances where drainage has led to the destruction of woodland, particularly wetlands, and to the destruction of a habitat for flora, fauna, and fish. This land has been removed from recreational, aesthetic and conservation uses. At the same time water reservoirs have been diminished, and natural streams have been polluted by agricultural drains. In urban-rural regions eight specific problems or conflicts have been identified and discussed in some detail (Chapter 7).

It has been pointed out that many of the situations involving conflicts in land use are either not serious or have not been substantiated. Yet other situations of serious conflict, where the advisability of drain construction is not easily determined, have been identified. In another class are conflicts where modifications to the project could probably have been satisfactory to all parties.

In view of these problems one can class the alternatives concerning drainage legislation into three categories: (1) instigate no change; (2) instigate radical changes to greatly centralize control and authority over the drainage of rural and, possibly, urban land; and (3) modify the current Drainage Act. Each of these alternatives is discussed in turn below.

8.2 Alternative 1: No Change in Legislation

The first alternative would permit a continuance of the kinds of problems already identified. For example, drains failing to lead to significant agricultural benefits would continue to be constructed. This and other problems appear to arise often enough to be of serious concern. Furthermore, some problems are bound to increase in frequency and severity, particularly in the most rapidly urbanizing portions of the province. Increasing urbanization leads to direct conflicts along the rural-urban fringe. Of probable greater importance, however, is the increase in ownership of rural land by persons who live and/or work in the city (Found and Morley, 1972). The number of persons who are not landowners but who use rural areas for recreation also rises. These various trends associated with urbanization create potential conflict situations in the countryside on a much larger scale than would occur in earlier stages of urbanization. Consequently, one can envisage problems which have been rather infrequent to date becoming much more severe and frequent in the areas surrounding growing towns, in the broad metropolitan regions (such as the Toronto-Centred Region), and in the habitual outdoor recreation areas of the province. Thus, no change in drainage legislation would fail

to ward off an increase of serious conflict situations as well as a continuance of those problems already evident.

8.3 Alternative 2: Radical Changes to Centralize Authority

One of the trends common in recent Ontario history is the tendency for certain types of administrative authority to be centralized. For example, county or other large-region school boards have replaced the former township or town boards. Local governments have been combined into large-region units. The advantages of centralization are said to include lower total administrative costs, particularly where former duplication of functions can be avoided; greater expertise in carrying out administrative functions through streamlining and "professionalization"; and better decision-making through large-scale planning. It is felt that large-scale planning is good since the conflicts that arise through local *ad hoc* decision making can be avoided and since the achievement of broad-level objectives can be realized.

One alternative to solving land drainage problems would be to place land drainage under a centralized authority, presumably one which would have rather large regional planning units. Such an authority might even become responsible for instigating drainage schemes, as is the case in the Province of Manitoba. The advantages of such a system could include the following:

(1) centralized authorities could maintain their own technical advisory staffs, which might lower the costs of planning projects (e.g. do away with the need for a private engineer's report);

(2) centralized planning could conveniently allow for the inputs of experts representing a number of fields and viewpoints so that potential land-use conflicts could be recognized in time for remedial action;

(3) the current *ad hoc* procedure of initiating drainage construction from place to place could be replaced with large-scale project planning. Larger drainage systems could be undertaken so that hydrological conflicts or incompatibilities between drains could be avoided, and the per-unit distance cost of construction could be lowered; and

(4) liaison between drain construction and related developments, such as the building of urban storm sewers or agricultural development programmes, could lead to a general and orderly regional development. Similar liason with conservation or other environmental interests could permit new drainage to enhance attempts to preserve wildlife, or build parks.

Such a system would or could have a number of disadvantages, however:

(1) the theoretical savings in cost might, in fact, become larger expenditures than are current. The low level of drainage activity in many regions might not justify the large costs associated with the development of a new centralized body;

(2) unless the centralized planning authority were to be one already in existence (e.g. the regional offices of the Ministry of Natural Resources) the development of a new authority would be bound to duplicate the considerable expertise already available across Ontario (e.g. the county Agricultural Representatives);

(3) the development of yet another large-scale planning or advisory unit would further complicate the administrative picture across Ontario. Clearly there is a need for the existing units concerned with Ontario's regional development (e.g. planning boards, various Ministry representatives, etc.) to coordinate their efforts as closely as possible. Even these groups have yet to develop very comprehensive or detailed plans for Ontario's rural regions, and the addition of another administrative group would probably make the solving of the general problem more difficult. It has been stated by some that Ontario is not yet "ready" for detailed regional planning in its rural regions. If this is true, the development of a special unit to administer land drainage might only make it more difficult to achieve; and

(4) the development of any new centralized system will require a great deal of effort to change current procedures.

The development, use, and conservation of water resources in Ontario is largely without any centralized direction and review; but it should be noted that recent legislation has moved the Government into a position from which considerable control over these matters could be exercised. It does not appear, however, that the powers granted are being exercised to anything like their fullest extent. The Ontario Water Resources Act is a case in point. This Act was previously known as The Ontario Water Resources Commission Act (R.S.O., 1970, Chapter 332). The original Act set up the Ontario Water Resources Commission, but recent legislation on government reorganization has abolished the Commission and placed the Act and the powers it confers directly under the Minister of the Environment.

The major powers of the Minister are set out in Section 17. Section 17 (1)(C) empowers the Minister

> to construct, acquire, provide, operate and maintain sewage works and to receive, treat and dispose of sewage delivered by municipalities and persons.

Sewage is defined as including drainage, and Section 31 (1) provides;

> for the purposes of this Act, the minister has the supervision of all surface waters and ground waters in Ontario.

The Water Resources Act could be used to initiate major drainage projects. At present the powers given by the Act are being primarily devoted to the supply and distribution of water to urban and semi-urban areas, and the collection and disposal of sewage and liquid wastes in the same area.

The Government actually has a further and more general power than that granted by The Water Resources Act. The province is vested with the constitutional responsibility for "local works" within the Province, and can establish any drainage projects it thinks desirable by special legislation. The Public Works Act (R.S.O., 1970, Chapter 393) sets out a wide variety of general powers which the Government can use on projects authorized by such legislation. On a local scale municipalities also have broad powers over matters related to drainage. Under Section 352 Subsection 16 of The Municipal Act (R.S.O., 1970, Chapter 284) all municipalities have the power to pass bylaws:

> for constructing, maintaining, improving, repairing, widening, altering, diverting and stopping up drains, sewers or water courses; for constructing, maintaining, repairing and improving dams; for providing an outlet

> for a sewer or establishing works or basins for the intersection of purification of sewage; for making all necessary connections therewith, and for acquiring land in or adjacent to the municipality for any such purposes.

Of course, The Municipal Act is not employed for the construction of agricultural drains since it does not provide for the sharing of costs by farmers and the Government as does the Drainage Act.

To summarize, there are a number of possible advantages and very serious disadvantages to the establishment of a new, centralized system for administering land drainage in rural areas. Much of the advantage rests on the advisability of utilizing large-scale planning and professional expertise to instigate or review drainage projects. But it has been pointed out that such expertise probably already exists in regions across the province, and that the Government already possesses powers to permit centralized and large-scale activity which are not being fully utilized.

8.4 Alternative 3: Changes in the Current Land Drainage Act

Changes in the current Land Drainage Act could be made which could help overcome the problems associated with land drainage which have been identified in this study. These possible changes will be discussed under the following five topics: project initiation, project review and the engineer's report, project approval, right of appeal on decisions, and urban-rural problems.

(a) project initiation

Under the present Act the primary initiators of projects are landowners in need of drainage. If all or a majority of affected land owners

agree on a common project they petition for an engineering report under Section 3 of the Act. A municipality can initiate a project under the same section if drainage is necessary for one of its highways. A single owner who needs a drainage project which would affect other owners files a requisition for an engineer's report under Section 4.

It might be advisable for the category of persons initiating projects to be broadened. A situation might arise where a majority of landowners refused to agree to the construction of a drain which would be highly beneficial and desirable to a minority group of avid farmers. This situation could arise, for example, in an area with large-scale ownership of land by persons from a city. Or it could arise where a large number of landowners occupied small ribbon-like plots of land amidst genuine farms. The problem might be met by basing the decision to undertake a project on land acreage rather than on the number of landowners. For example, each property owner might obtain one vote for every acre he owned; or some system mid-way between this scheme and the current procedure might appear to be more fair. Another solution might be to allow municipalities to initiate projects where no question of highway drainage was present and where less than a majority of affected owners desired it. This would have the added advantage of permitting municipalities to effect large-scale plans in their efforts to reach "regional" objectives.

Although broadening the powers of initiation might help overcome some current problems, considerable disadvantages can be foreseen. A serious problem relates to cost sharing, and another to the fact that municipalities already have fairly broad powers of initiation, powers which could be broader with modifications to Acts other than the Drainage Act. The present

scheme depends upon distributing the costs of drainage installation and maintenance among parties requesting the project. Where a single individual requisitions a drainage project he must be prepared to pay for inconvenience suffered by other persons who have no interest in the work. At present municipalities could initiate drainage schemes outside of the Drainage Act by virtue of their general powers under the Municipal Act. They could not, of course, distribute their costs among the parties benefited if they used this approach. It is arguable that they could initiate a drainage project under Section 2 (1)(d) of the Local Improvement Act and thereby distribute costs among benefiting parties, but it would appear that agricultural outlet drains are not really contemplated in the Act. If further municipal powers of drainage installation are desired it might be useful to amend the Local Improvement Act rather than the Drainage Act. The problem of cost sharing becomes even more acute when parties not directly interested in the land are given the power to request installation of projects. In these circumstances there would be no excuse whatever to distribute installation and maintenance costs among affected lands, and there would be a strong argument that affected landowners should be compensated for interference with their property at the time of installation. The project would have to be of considerable importance to force a municipality to bear this entire cost. Clearly, such a power of initiation would be pointless if the individual interested parties had to bear the entire cost. If municipalities were given extra powers to install outlet drains under the Local Improvement Act interested individuals other than landowners might be allowed to act as petitioners under an amendment to Section 11 of that Act. This would provide a mechanism for

other interested parties to seek the installation of drainage projects, but it would remain highly unlikely that a municipality would install a project over the objections of landowners themselves.

(b) project review and the engineer's report

As has been suggested in various sections of this study, drainage projects can be approved without much prior evaluation as to the agricultural benefits involved or of the possible environmental damage or other land-use conflicts. It might well be possible to avoid some of these difficulties at an early stage, either during or prior to preparation of the engineer's report.

Under the Drainage Act projects which are petitioned for under Section 3 are treated in a manner different from projects which are requisitioned under Section 4. Where a majority of owners has petitioned for a project, municipal council must first notify the local conservation authority having jurisdiction over the area of the petition. Thirty days after such notification an engineer is appointed to study the proposal and report on the project. Where a project is requisitioned under Section 4 an engineer is appointed immediately, and the engineer must serve notice on owners affected by the suggested project before beginning his work.

It would be useful if bodies other than the conservation authorities were given notice of proposed drainage projects prior to the preparation of an engineer's report.

Also, there seems to be little reason why procedures should be different under Sections 3 and 4, since similar potential problems exist for both petition and requisition drains. In Chapter 7 the idea of a regional drainage committee, which might consist of representatives from

groups such as the District Offices of the Ministry of Natural Resources, the relevant conservation authority, or the Department of Agriculture and Food was suggested. Such a group, which might also include an engineer, could probably identify, with little research, drains which were obviously undesirable, and could suggest to the council that funds not be wasted on an engineer's report. If the work of the proposed project appeared to be questionable or good then an engineer's report could be recommended. A possible simple procedure for obtaining the inputs from a group representing a range of expertise would be to send a form letter to each member describing a proposed project and requiring a written response. Such responses might be routine in the vast majority of cases, indicating that no problems with the project are foreseen. If these bodies presented objections to the proposed scheme the municipal council could notify the interested property owners of the objections and give such owners a right to seek and present contrary opinions. The council could then exercise its discretion as to whether or not to seek an engineer's report.

The present Drainage Act sets out a number of requirements for the engineer's report. The report is to include "plans, specifications, estimates of the drainage works, and an assessment against the lands and roads within the area requiring drainage. . . . stating . . . the proportion of the cost of the drainage works . . . to be assessed against every parcel of land and road for benefit, outlet liability and injuring liability." (Section 3 (1)). Section 3 (1) also requires the engineer to indicate in his report the manner in which the spoil from the drainage project shall be disposed of. The engineer's report when complete is

filed with the municipal clerk (see Section 2.2(1)). It might be advisable for the engineer's report to be broadened to include a detailed description of the site in question, a description of all existing land use on the site, a recommendation on farm underdrainage which might be usefully associated with the outlet drain project, probable changes in land use following completion of the project, and suggestions on alternative means of meeting the problems of the site. This may require more than an engineer's normal expertise, but if it could be accomplished, even in a rudimentary form, it should be of great assistance in assessing the potential benefits of the project and in considering alternative ones. The assistance of supplementary expertise, such as that provided by the local agricultural representative, might facilitate the procedure.

It could be useful if the Drainage Act were to make additional certain other types of information specifications, which would help ensure a good physical basis for drain construction. Specifically, information concerning the slope angles of the sides of the drain, plans to revegetate the excavated ditch banks, and plans for disposition of the spoil could be included. It has been noted that drains often fail to meet desirable standards in these regards. For example, slope angles are sometimes too steep to be stable, revegetation is not provided for, and spoil is left in awkward locations. A modified Act would require engineers and contractors to comply with these specifications.

The high cost of obtaining an engineer's report has been referred to a number of times in the briefs to the Select Committee on Land Drainage. A suggestion to possibly overcome this problem is for regions

(perhaps counties or other appropriate areas) to hire a permanent engineer to prepare all reports. This could be a useful suggestion if the area concerned had enough projects on a regular basis to occupy the time of the engineer. In some parts of the province this would not be the case, and the saving of doing away with private engineers' reports would not pay the salary of the full-time appointment. Some consideration might be given to assigning the preparation of the reports to existing civil servants (e.g. other county engineers). Of course, it might be difficult to find existing personnel with the appropriate experience. An added advantage of hiring a permanent engineer would be that the costs of preparing reports would be distributed equally over all property owners, and not fall solely on the shoulders of those requesting drainage construction.

(c) project approval

The Drainage Act now provides that if the engineer files a negative report no further steps are taken by the council unless the report is appealed from (see Section 8 (10)). If the engineer's report is favourable and is the result of an individual requisition section 4(a) requires that the municipality adopt it. If, however, a favourable report is for a project initiated by petition the municipality has a discretion as to whether or not to adopt it (see Section 26 (1)). In either case a copy of the report must be sent to other municipalities, conservation authorities, public utilities, the Minister of Natural Resources, and all other owners, in so far as any of those parties are affected by the proposed act (see Section 24 (1)(2)(3)). It is probably at this point, rather than at a point of initial review, that objections of an agricultural

ecological, or conflict nature could be most profitably advanced since the parties concerned would have more information on which to base opinions.

It would seem advisable for the approval process to be the same for both petitioned and requisitioned projects, as both have the same potential problems. If the petition procedure is accepted this would give the municipal council discretionary power to approve or disapprove of a requisitioned project. It would seem to be highly desirable for the current list of bodies to be notified of projects *whether or not* they own land affected by them, and for some representative with agricultural expertise (e.g. the local agricultural representative) to be added. This would permit some review of the agricultural benefits to be expected from a project. As with the pre-report review suggested above, it might be appropriate to require a written response, no matter how simple, from the bodies notified before a council makes a final decision on a drain. This should ensure that all relevant bodies have given some consideration to the potential effects of the project. If the earlier suggestion that the engineer include in his report recommendations on associated farm underdrainage were to be adopted the landowners could automatically get this advice when they get the report. Section 24 might be amended to require municipal councils also to advise farmers as to whether or not the municipality has passed bylaws under the *Tile Drainage Act* to make tile drainage loans available.

The Act now states no criteria on which drainage projects should be judged. The implication is that any project which can be favourably reported on by an engineer is worthy of consideration and approval.

Section 26 might be amended to state that the municipal council shall consider such matters as, the potential for increased productivity, the relationship between the potential productivity and the cost of the installation, the possibility of ecological damage, and undesirable land-use conflicts when considering whether or not to approve the report.

(d) right of appeal on decisions

The present Act allows two types of appeals: appeals with regard to the costs of the project, and appeals with regard to the advisability of the project. The assessment of costs of construction and maintenance against individual parcels of land can be appealed under Sections 31 and 33. Where land has been benefited by a project and is then severed its project assessment will be apportioned between the various parcels. This apportionment can be appealed under Section 19. The engineer's bill for fees can be appealed under Section 23. The substantive decision with regard to the approval of the drainage project can also be appealed. In this case the appeal is to the provincially appointed Drainage Referee. Conservation authorities can appeal municipal approval of a project on the grounds that "the drainage works will injuriously affect the scheme undertaken by the authority" (see Section 35). Landowners or utilities affected by the project can appeal on the grounds, Inter Alia, that "the benefits to be derived from the drainage works should be modified" (see Section 36). An owner may appeal a negative engineer's report to the Referee under Section 37, and other municipalities affected by the project may appeal on a variety of grounds under Section 38.

It might be advisable that any members of a wider group entitled to intervene in a project at the initial review and approval stage be given

a right to appeal approval. This suggestion could be effected by broadening the parties entitled to appeal under Section 36. At the same time the grounds for appeal could be extended to include inadequate consideration of the potential for agricultural production, ecological damage, or land-use conflicts.

The problems with these suggestions is somewhat the same as the problem raised by broadening the entitlement to initiate projects. The costs involved in appeals of this nature can be very extensive. Even if the parties wishing to question the project can bear their own costs of appeal should the landowners primarily affected be forced to undertake such extra costs? If the rights of appeal are broadened it might be necessary to include a requirement that parties not directly interested in the land affected post a bond to cover the cost of appeal before being given standing to appeal.

A further question exists with regard to whether or not broadened access to the present appeal structure is a useful innovation. The evidence is that the Drainage Referee does not now play a significant role in these matters and is not being frequently called upon to review decisions. If there was evidence that a large body of people were desirous of intervening on drainage decisons it might be useful to set up an entirely new tribunal. Such a tribunal might, like the Ontario Municipal Board, hold public hearings in various areas as problems arise. In the light of the lack of conflicts encountered in this study, however, it would appear that a suggestion of this nature is, at the best, premature.

(e) urban-rural problems

While the present Act does not directly address itself to the difficulties which can arise when urban and rural land uses conflict in a single drainage area, it has provisions which should, in theory, meet many of the problems raised. When land which has been assessed for a drainage project is subdivided the various parcels themselves become responsible for the project. The clerk of the municipality calls in an engineer to apportion the assessments (see Section 19). This assessment carries with it the responsibility for the cost of maintaining the drainage system (see Section 46 and 49). Persons whose land ajoins drainage works are responsible for the maintenance of the free flow of the water in those works, and can be forced to pay the cost of removing obstructions in the drainage system which they have caused (see Section 55). Finally any person who "obstructs, fills up or injures or destroys by any means any drainage works" is guilty of an offence under Section 58 and can be fined or imprisoned.

It is difficult to determine what further steps might be taken to alleviate the problems of these conflicting uses except to suggest that representatives of urban areas (e.g. planning boards) might be included in any group given a formal role in the pre- and post-report stages of a project. The situation probably is that many appropriate and necessary powers are present but are not being exercised. Perhaps what is needed is an enforcement mechanism which is easily available to farmers or urbanites. Section 12 of the Act allows local councils to appoint drainage commissioners to "supervise the maintenance of any drainage works." Where drainage commissioners are present it should be relatively easy for them to enforce

the obligations. If no drainage commissioners are being appointed perhaps some other local official (for example, the agricultural representative or the roads superintendent) should be empowered to view drains and enforce their maintenance upon request by affected landowners. The Planning Act might be amended to force committees of adjustment to consider the local drainage pattern when severances are being requested. The steps in the approval of subdivision plans under the Planning Act are not at present given statutory definition--they remain within the discretion of the Department of Treasury and Economics. The Department might be advised of the problem and be requested to have regard to drainage patterns when reviewing subdivision proposals.

8.5 Conclusions

A number of possible changes (and non-changes) in drainage legislation have been outlined, together with some consideration of their likely advantages and disadvantages. A very important factor to bear in mind in considering changes is the revealed need for change. To what extent have problems arisen with current legislation in force? This study has shown that problems certainly have arisen. A significant proportion of projects recently completed appear to have failed to generate enough agricultural benefits to justify their construction. Evidence of environmental damage and genuine rural-urban land-use conflicts has also been gathered. Yet the majority of projects appear to have been wise investments from an agricultural point of view, and the frequency and intensity of environmental and other land-use conflicts appear to be less severe than many of the presentations to the Select Committee on Land Drainage have suggested.

There is no grave crisis at present. However, a revised system which would permit an evaluation of the potential impacts of a project by experts in a number of fields should ensure that the minority of projects which do lead to problems could be modified or stopped. The researchers believe that such an evaluation procedure is practicable.

Reference

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Chapter 9

SUMMARY AND CONCLUSIONS

9.1 Introduction

This study has involved a general investigation of government-assisted land drainage in Ontario. The detailed analyses have included both an evaluation of the full benefits and costs associated with a sample of 37 drainage projects located in seven sample townships, and more specific studies relating to conflicts between agricultural land drainage and competing land uses. In this chapter a summary of the research is presented and conclusions are drawn. The conclusions are presented in the form of answers to four specific questions: (1) What have been the "full" benefits and costs of recent drainage activity in Ontario? (2) Can the full benefits and costs of drainage projects be effectively evaluated, and is prior evaluation feasible? (3) To what degree are conflicts between competing land uses and, more generally, between public and private interests present with respect to land drainage in Ontario? (4) What changes may be necessary in existing policies and legislation in order to better provide for the prior evaluation of benefits and costs and for the solution of conflicts?

9.2 Summary

The research for the project involved four phases: inventory and hypothesis formulation, selection of sites for detailed study, field investigation and data collection, and analysis and evaluation of results.

The first phase of the research, inventory and hypothesis formulation, involved a review of literature relating to land drainage and its impacts, a

township-level study of the patterns of drainage activity over the 1964-1972 period, and the preparation of conceptual models detailing the potential impacts of land drainage activity. The overview of land drainage during the 1964-1972 period has been presented in Chapter 2. The basic data sets employed were the government records of expenditures on grants to municipalities under The Drainage Act, and government purchases of debentures from municipalities under The Tile Drainage Act. The analysis of the data involved both the magnitudes and the regional patterns of expenditures. The magnitudes of the annual total provincial expenditures on grants under The Drainage Act for the period 1962-1972 were examined and revealed a period of relatively stable expenditures up to 1965, a period of rapid expansion of drainage activity from 1966-1969, a leveling off of activity to 1971, and a drop in 1972. This pattern of activity was explained on the basis of the various programmes of government assistance which were available. In particular, the 1966-1969 period of rapid expansion of drainage activity corresponds to the time during which special ARDA assistance was available, while the stable period from 1969-1971 was the period during which the Ontario Department of Agriculture and Food's Special Drainage Assistance Programme was in force. An examination of the annual total provincial expenditures under The Tile Drainage Act revealed a pattern quite similar to that for The Drainage Act expenditures. This pattern seemed to indicate that tile drainage activity is closely related to and follows behind municipal drainage activity.

In order to analyse the regional patterns of drainage activity during the 1964-1971 period a series of township-level maps of drainage expenditures were prepared. These maps provided a basis for the identification of seven regions of drainage activity. The first two regions identified, the

Southwestern Ontario Region and the Southwestern Ontario Fringe Region, represent the areas of maximum drainage expenditures and maximum increases in drainage expenditures. These areas, which correspond to the prosperous agricultural areas of Southwestern Ontario, completely dominate the expenditure patterns under both The Drainage Act and The Tile Drainage Act. The third area identified was the Southern Georgian Bay Region, which in recent years has experienced considerable increases in activity under both The Drainage Act and The Tile Drainage Act. The fourth region of activity, that of Eastern Ontario, represents a secondary centre of activity which has been growing in importance. The fifth and sixth regions identified, Niagara and The North Shore of Lake Ontario Areas, were characterized as areas with considerable expansion of tile drainage activity, but very little expenditure on municipal drainage. The final region identified, Northern Ontario, contains only a few localized areas of limited drainage activity. The overview of the regional patterns of drainage activity served to emphasize the dominating position of the areas of Southwestern Ontario with lesser centres of recent activity south of Georgian Bay and in Eastern Ontario.

In addition to the overview of drainage activity, the first phase of the research project involved the formulation of hypotheses with respect to the impacts of land drainage. Following a review of the available literature, the direct and "indirect" impacts of land drainage were generalized into three categories: agricultural impacts, environmental impacts, and impacts on non-agricultural land uses. The potential agricultural impacts included impacts on agricultural labour and capital inputs, the quantity, type, and value of agricultural production, and, ultimately, the value of agricultural land. The potential environmental impacts included impacts on the level of water tables, the quantity and quality of streamflow, and vegetation and

wildlife. The potential impacts on non-agricultural land uses included impacts on recreation, forestry, fur trapping and all uses depending on stream and groundwater supplies. All of the various potential impacts were summarized in two models, one at the local and one at the large scale (Chapter 3). The two scales were necessary in recognition that some impacts which are not recorded at the local scale may be recorded at the larger scale and vice versa. These models provided the conceptual basis for the analysis which followed.

The second major phase of the research involved the selection of sites for detailed study. These sites were of two types: (1) seven townships distributed across the province within which drain-level surveys were to be undertaken, and (2) a series of specific sites for the study of special problems, particularly those relating to conflicts between competing land uses.

The seven townships selected for drain level analysis were intended to provide fairly "typical" province-wide coverage representing a broad variety of conditions. The townships selected were Brooke (Lambton County), Mersea (Essex County) and Ellice (Perth County), representatives of the Southwestern Ontario region; West Luther (Wellington County), representative of the Southern Georgian Bay area; Cumberland (Regional Municipality of Ottawa-Carleton) and Ramsay (Lanark County), representatives of Eastern Ontario; and Caldwell (Nipissing District), representative of Northern Ontario. Within each of the townships a sample of five or six individual drainage projects was selected for detailed study; and, for each of the projects a sample of properties was selected for questionnaire survey. Each of the seven sample townships had approximately 40 properties selected for examination. In the questionnaire survey the owner or manager of each of the properties was

asked a large number of questions designed to obtain information on the full range of drain-construction impacts. The results of the questionnaire survey provided the basis for the assessment of agricultural benefit-cost ratios and environmental impacts.

The second group of sites selected for detailed analysis included several individual drainage projects which involved cases of known conflicts between competing land uses. In one case the project involved a water storage area, and, in another, the project involved a wildlife and recreation area. The final case concerned an urban fringe area.

The third phase of the project centred on the collection of data. This phase included the questionnaire surveys, field investigations, and a series of interviews with various authorities. The questionnaire survey included the administering of the questionnaire, both for the sample properties in the seven townships and for a sample of the properties associated with the special cases investigated. Other types of field investigations were also undertaken in each of the special cases. Finally, a series of interviews was undertaken with representatives of various government agencies and universities.

The final phase of the project involved the data analysis, the evaluation of the results, and the drawing of conclusions. Discussions of the agricultural benefits and costs and of the environmental impacts of land drainage have been presented in Chapters 5 and 6 respectively. Chapter 7 presented an analysis of the special cases of conflict between competing land uses.

The property-level questionnaire provided a basis for the detailed calculation of benefit-cost ratios for each of the sample drains. In each case the benefit-cost ratio was obtained by dividing the total cost of the drain into the present value of all current and future net returns from

agriculture which would not have occurred without the construction of the drain. In general the benefit-cost ratios calculated for the sample drainage projects indicated that agricultural benefits are being derived, and that a majority of benefit-cost ratios exceed 1.0. However, the detailed calculations also revealed considerable inter-township and inter-drain variation in the magnitudes of the benefit-cost ratios, as well as a significant number of very low ratios. For example, assuming a 20-year drain life and 6 percent interest rate (both very "generous" assumptions), 11 out of 37 drains have ratios below 1.0. The highest township-level benefit-cost ratios were calculated for the three sample townships in Southwestern Ontario, the area of traditional high agricultural productivity. The benefit-cost ratios calculated on the basis of a 12-year drain lifetime and an eight percent interest rate were for Brooke--2.13, Ellice--5.37 and Mersea--3.26. In contrast the comparable benefit-cost ratios for the townships in the "frontier" areas of drainage activity were considerably lower: Caldwell--.94, Cumberland--.49, Ramsay--1.80, and West Luther--.86. It is also important to recognize that within a given township there is considerable variation in the benefit-cost ratio for individual projects. For example, in Mersea where the overall benefit-cost ratio is high, two of the five drains examined have ratios of less than 1.0.

While it was a relatively straight-forward problem to calculate the magnitudes of the agricultural impacts of drainage, the estimation of environmental impacts presented a more difficult situation. An extensive review of the published literature revealed a strong theoretical basis for wide-ranging environmental impacts resulting from land drainage activity. These theoretical environmental impacts have been incorporated into the local and large-scale models of the impacts of land drainage presented in Chapter 3. In Chapter 6

the environmental impacts of land drainage are discussed in considerable detail. In particular the impacts discussed include those on natural vegetation, wildlife, streams and lakes, wetlands, and ground water. Unfortunately, there has been very little research into the environmental consequences of land drainage undertaken in Ontario, and for this reason, much of the material discussed is based on examples from the United States.

In an attempt to evaluate the present situation with respect to environmental impacts in Ontario, the briefs to the Select Committee were reviewed, numerous interviews were undertaken, and the questionnaires from the seven sample townships were analysed. On the basis of the researchers' survey in the seven sample townships it is possible to make several generalizations. Most agricultural drainage projects tend to be on a relatively small scale involving drains two or three miles long and drainage areas of between 500 and 1500 acres. In general terms the environmental impacts of such projects when considered individually are limited; however, the cummulative impacts of many such projects may involve serious effects. In an effort to determine the extent of environmental impact associated with the rapid increase in drainage activity during the past few years detailed surveys within the seven sample townships were undertaken. These surveys indicated that most of the recent drainage activity has involved the reconstruction of existing drains rather than drainage of large areas of new land. This observation was confirmed by an air photograph survey of wetland and woodlot areas recently cleared for agriculture and streams recently channelized. On the basis both of the researchers' review of the briefs to the Select Committee and of the numerous interviews undertaken with environmental authorities it is possible to generalize to the provincial scale. While the vast majority of land drainage projects do not have serious

detrimental effects on the environment, a minority of projects do involve serious impacts. For example, in the areas north and west of Toronto a rapid rate of wetland destruction has been observed.

While the environmental impacts of individual drainage projects tend to be minor, it is important to recognize the potentially serious cummulative effects of a number of projects viewed on a larger scale. The seriousness of such impacts may be particularly pronounced in areas such as Southwestern Ontario, where the remaining areas of permanent wetlands and natural streams have been reduced to critical levels. The cummulative effects of numerous small projects must also be recognized with respect to physical hydrology. Water tables may be lowered and downstream impacts on streamflow may include increased flooding and a reduction in the low flows. On the basis of this survey it is obvious that a considerable amount of detailed research is required in order to more clearly ascertain the large-scale impacts of drainage on the environment.

In addition to the study of land drainage projects in the seven sample townships, additional projects were selected for the analysis of conflicts relating to competing land uses. The two conflict situations considered involved wetlands and urban-rural problems. Two major approaches to the study of these problems were employed. First was an examination of the briefs to the Select Committee, and second was the undertaking of case studies.

Two case studies involving wetland conflicts were undertaken. The first study involved the Martin Drain in Brant County, which entailed the ditching of a water storage area which was owned by a conservation authority. The second case was that of the 8th Line Municipal Drain in Simcoe County, which involved the drainage of the Stroud Swamp, an area of some importance for wildlife and recreational hunting. In both cases communication between

conflicting parties appeared to be lacking, and there is reason to believe that the projects should not have gone ahead without modifications.

The urban-rural case study involved a project on the outskirts of Niagara Falls. In this case several natural streams have been modified, and areas of agricultural land expropriated for drainage construction. Again a basic problem relates to a lack of communication and knowledge, which has prevented a suitable compromise from being worked out. In view of the documented impacts and conflicts relating to drainage construction the researchers have undertaken to consider several possible alterations to existing legislation and policies. These suggestions have been discussed in Chapter 8.

9.3 Conclusions

(a) What have been the full benefits and costs of recent drainage activity in Ontario?

Following this study it is possible to make some general statements about the impacts of land drainage at the "local" scale. Analysis of the drains in the sample, which should be fairly representative of the Province as a whole, indicates that a majority of projects has led to increases in agricultural production, the value of which exceeds the cost of the projects. In these cases, the agricultural benefits have outweighed the costs. In a large minority of cases, however, agricultural benefits have not been as high as the costs. The regional pattern of the benefit-cost situation is such that Southwestern Ontario has obtained the highest benefits, and the areas of lower agricultural productivity have often tended to incur more costs than benefits. But one must be wary of over-simplification, since considerable variation in the benefit-cost balance is evident between drains, even within

single townships.

Environmental impacts when viewed at the local scale have tended not to be excessively detrimental. Most projects have had few local effects which are normally considered to be damaging, although a number of situations have been documented with varying degrees of damage. Regions of some concern are (1) Southwestern Ontario, where the expansion of cultivatable acreage has led to the disappearance of some of the limited area of wetland and other woodland, and (2) the area north of Toronto, where urban-created demands have led to the drainage of wetlands.

The scope of this study has not permitted the reaching of very accurate conclusions about the large-scale impacts of drainage. Concerning agriculture, the increased production which results from drainage has certainly led to some increase in the supply of food; but it is not possible to state the extent to which this has reduced food prices, stimulated other sectors of the economy, or depressed overall farm incomes. Concerning environmental impacts, one can only speculate as to large-scale responses to drainage. One tangible item is the disappearance of wetlands, which does not appear to have been a very serious problem in the last decade. Hydrological impacts are more difficult to assess. Although the hydrological impacts at the local scale, appear to be almost insignificant the aggregate effects are still largely unknown. On the whole, the accurate determination of large-scale environmental impacts requires years of careful monitoring and research.

As a final point one should note that it is difficult to assess overall benefits and costs in the absence of a common value system for agricultural, environmental, and other factors. Clearly, it is inappropriate to attempt measurement on a common scale. The problem of evaluation could be eased considerably, however, if the Province, or regions within the Province, had

clearly-stated rural land-use objectives, priorities, or policies.

(b) <u>Can the full benefits and costs of drainage projects be evaluated, and is prior evaluation feasible?</u>

On the basis of the present study it is possible to reply in the affirmative to the above question. Although it is not feasible to complete a detailed benefit-cost analysis for a proposed project, such an analysis is not really necessary. Any proposed drainage project can be categorized into one of three groupings on the basis of its benefits and costs. The first group includes projects for which the agricultural benefits are high and the environmental impacts are minor. The second group includes projects for which the agricultural benefits are low and the environmental impacts are not serious. The final group includes projects for which both the agricultural benefits and the environmental impacts are considerable. Projects which fall into the first two categories can be identified with little research, and the decisions should be straight-forward. Only projects which fall into the third category require detailed assessment.

In the final section of Chapter 5 it was suggested that the variation in the benefit-cost ratios for the sample projects could be accounted for by seven factors: the productivity of the environment, the installation of field underdrainage, special hydrological conditions, local initiative, type of project, quality of engineering, and weather conditions since project completion. All except the last of the factors can be evaluated, estimated, or controlled before construction is initiated. In most cases a simple evaluation of the existing land-use patterns, the soil types, and the attitudes or plans of the local landowners would provide a suitable basis for the assessment of the expected agricultural benefits and costs.

Similarly, evaluations of environmental impacts could be prepared without

excessive effort. Environmental impact evaluations could aim to estimate unavoidable adverse effects, irresversible commitments of resources, and any alternative schemes? It should be noted that many agencies are already accustomed to preparing statements of this nature.

While it is certainly feasible to complete a prior assessment of the agricultural and environmental impacts of proposed drainage projects, the proper interpretation of such impacts can only be achieved on the basis of established land-use priorities.

(c) <u>To what degree are conflicts between competing land uses and more generally between public and private interests present with respect to land drainage in Ontario?</u>

Although several cases of serious conflicts between competing land uses have been documented in Chapter 7, the findings of this study suggest that the vast majority of drainage projects do not involve such conflicts. Where such conflicts do exist they can usually be classified into one of three situations. These situations are conflicts relating to land use in the rural-urban fringe, conflicts relating to the loss of wetlands and conflicts relating to effects on natural streams. It is significant to note that in the minority of cases in which conflicts develop, the present procedures for obtaining approval for drain construction, particularly under The Drainage Act, do not seem to be adequate to deal with the problems.

(d) <u>What changes may be necessary in existing policies and legislation in order to better provide for the prior evaluation of benefits and costs and for the solution of conflicts?</u>

This project has documented the need for some degree of change in the present policies and legislation if problems relating to agricultural benefits and costs and potential conflicts between competing land uses are to be overcome. Three possible alternatives have been discussed in Chapter 8: (1) instigate no change, (2) instigate radical changes to greatly centralize

control and authority over the drainage of rural and possibly urban land, and (3) modify the current Drainage Act. It has been suggested that the minimum changes required should provide a basis both for a more complete prior evaluation of agricultural benefits and costs in order to avoid the construction of uneconomic projects, and for a mechanism for the evaluation of conflicts relating to competing land uses.

Appendix 1

LIST OF PERSONS WHO ASSISTED DURING THE COURSE OF THE PROJECT*

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*The authors apologize for the ommission of the names of any persons who should have been included in this list, and offer their sincerest thanks to them.

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Appendix 2

QUESTIONNAIRE USED FOR SAMPLE FARMS

No.________

DEPARTMENT OF GEOGRAPHY

YORK UNIVERSITY

TORONTO ONTARIO

1. I'm from York University. We are conducting a survey on factors affecting agriculture for the Ontario Department of Agriculture and Food. May I speak to the owner or tenant of this farm?

2. Interviewee: ______________________________

Lot and Concession: ______________________________

Township: ______________________________

---

3. Do you:

Own the farm? (Skip to Q.4)............. 1
Rent the farm?.......................... 2
Have another leasing arrangement? (Specify)______________ 3

---

4. What kind of leasing arrangement do you have with the owner?

Rental without cost & profit sharing.... 1
Rental sharing costs & profits.......... 2
Rental sharing costs only.............. 3
Other................................... 4

---

5. What are the most important problems that farmers in this area have to face? (Probe: Any other problems?)

No important problems.................. 0
Mentions drainage...................... 1
Does not mention drainage.............. 2
Don't know............................. 3

No.__________

I'd like to concentrate now on questions related to land drainage.

6. What have been the major advantages of land drainage on your farm? (Circle each advantage mentioned)

No advantages	0
Crop yields increased	1
Crop quality increased	2
Decreased winter kills	3
Greater variety of crops possible	4
Growing area increased	5
Harvesting area increased	6
Irrigation water from drain	7
Legume longevity increased	8
Reduces time and cost to work land	9
Timeliness and flexibility of field operations..	X
Others (specify) ______________________________	

---

7. What have been the major disadvantages of land drainage on your farm? (Circle each disadvantage mentioned)

No disadvantages	0
Crop yield decreased	1
Crop quality decreased	2
Decreased farm water supply	3
Drainage cost exceeds value of crops produced ..	4
Impedes movements on farm	5
Irrigation became necessary	6
Soil became too dry	7
Unsuitable land is cropped	8
Undesirable effects on adjacent areas	9
specify ______________________________________	
Wheeled digger decreases soil quality in root zone.	10
Others (specify) ______________________________	

I would like to talk to you now about drainage in the area shown on this map (indicate drain, cultural features and land use).

8. Was there previously a drain in this area before the most recent one was contracted?

Don't know (skip to Question 13)	0
No (skip to Question 13)	1
Yes	2

---

9. Approximately when was it built?

________ year

No._________

10. Did the Government assist financially in its construction?

Don't know	0
No	1
Yes	2

---

11. What kind of a drain was it?

- Award drains	1
- Municipal	2
- Neighbours drain	3

---

12. Was the drain

- Open	1
- Tile	2
- Combination	3

---

13. When was the recent project completed on or near your property?

1.________ years ago.
2. don't know.

---

14. What was the nature of the project? (circle one or more)

new drain (skip to Question 17)	1
dredging (cleaning & deepening)	2
tree removal	3
extension	4
new culverts	5
replacement of tile	6
other (specify) ________________________	7

---

15. When was maintenance on the drain last undertaken prior to this project?

don't know	0
________ years ago	1

---

16. When was maintenance undertaken prior to that?

don't know	0
________ years before..........................	1

---

17. Do you have any tile drainage in the area affected by the drain?

don't know (skip to Question 22)	0
no (skip to Question 22)	1
yes	2

No.__________

18. Did your farm have tile drainage in the area affected by the drain prior to the project?

don't know	0
no	1
yes	2

---

19. Since the project have you installed tile drainage which connects to the drain?

no	1
yes	2

---

20. Please indicate (on map and in table) the specifications about all farm drainage which connects into the drain.

Year	Open ditch	Tile			No. of feet	Acres Affected	Cost
		clay	plastic	concrete			

21. How often do your tile drains require cleaning out?

don't know	0
never	1
every _____ years	2

---

22. Do you intend to install (additional) tile drainage on your land which connects to the drain?

don't know	0
no	1
yes	2

---

23. Is the outlet drain deep enough for field tile drainage?

don't know	0
no	1
yes	2

No.________

24. How many acres of your land were subject to standing water or were swampy in the Spring before the drainage project was completed?

In Spring	
before drainage (acres)	after drainage (acres)

25. How many acres of your land were subject to standing water or were swampy at other seasons before the drainage project was completed (if none go to Question 27).

Specify season ________

before drainage (acres)	after drainage (acres)

26. Is it the same land which has excess water in different seasons described above?

No 1
Yes 2

27. Indicate on the map the area which you think was affected by the recent drainage project.

28. How many acres were affected? ________ acres

29. How do you decide what areas were affected by the drain?

____

____

____

30. Have you changed land uses since the drainage project was completed?

No (skip to Question 33).. 1
Yes 2

No. ________

31. If the change was on the drained land, or if it was made possible by the drainage project, indicate the change in land use on your property following the project. (Also, locate the areas having undergone change on the map.)

Present		Before Drainage	
Land use	Acres	Land use	Acres

32. Why did you make this change? ______________________________

____

____

33. Have you changed your crop rotation since the drainage project was completed?

No (skip to Q.35) 1
Yes 2

34. If the rotation change was related to the drainage project, please describe it.

Present rotation	Rotation before drainage

35. Do you intend to make any future changes in crops or crop rotations because of the drainage project?

No (skip to Q.38) 1
Yes 2

____

36. Describe the change. ______________________________

____

____

____

37. Why will you make this change? ______________________________

____

____

No.________

38. Indicate crop yield changes following completion of the drainage project (+ or -).

Crop	Acreage involved	Use of crop	% Yield Change				
			0	1-10	11-25	26-50	>50

39. If you have any more specific figures concerning crop yield changes related to drainage please describe the area and circumstances and complete the table below.

Crop	Acreage involved	Yield before drainage	Period of Record	Yield after drainage	Period of Record

40. If you experienced a major crop yield change, could other factors, in addition to drainage, have contributed?

No 0
Seed change 1
Fertilizers 2
Climate 3
Equipment 4
Others (specify)________ 5

____

41. Do you anticipate any future crop yield changes related to the project?

don't know 0
No (skip to Q. 44) 1
Yes 2

42. What changes are expected?

Crop	Acreage involved	Present Yield	Future Yield

No.__________

43. Why do you anticipate this change? ____________________________

44. Have you altered the rate of fertilizer application for any crop on the acreage drained following completion of the project?

No (skip to Q. 47) 1
Yes 2

45. Indicate change:

Crop	Acreage involved	Application rate prior to project	Application rate after project

46. Why did you change the rate of fertilizer application? ____________

47. Can you seed earlier in the spring, now than you could before the drainage project?

No (skip to Q. 49) 1
Yes 2

48. On average, how many days earlier?

__________ days

49. Did the drainage project affect your crop harvesting?

No (skip to Q. 51) 1
Yes 2

50. What has the effect on crop harvesting been? ____________________

No.__________

51. What kind of well do you have?

shallow dug well	1
deep well	2

---

52. Did the drainage project affect your well level?

don't know (skip to Q. 54)	0
No (skip to Q. 54)	1
Yes	2

---

53. How large a change (+ or -)? ______________________________

---

54. Have there been general water level changes in your well over the years before the drainage project?

don't know (skip to Q. 56)	0
No (skip to Q. 56)	1
Yes	2

---

55. How often and how large were the changes?

Years	Change (+ or -)

---

56. Does the drain dry up during the summer?

No (skip to Q. 58)	1
Yes	2

---

57. For how long? ______________________days

---

58. Does the drain overflow its banks during spring runoff?

Never	0
Sometimes	1
Each Year	2

---

59. How often do you expect drain maintenance will be required

1-5 years	1
6-10 years	2
11-15 years	3
16-20 years	4
21-25 years	5
26-30 years	6
31-40 years	7
more than 40 years	8

No.________

60. Did the project drain any swamp or marsh on your farm?

No (skip to Q.62) 1
Yes 2

---

61. How many acres of swamp or marsh were drained? ___________acres

---

62. Did the project affect any woodlot on your farm? How?

No (skip to Q.66) 1
Yes 2

---

63. How many acres of woodlot were cleared as a result of the drain? ________acres

---

64. How many board feet of timber were sold from the clearing operation?

______________board feet

---

65. What was the woodlot used for prior to drainage?

not used 0
grazing cattle 1
fuel 2
timber 3
hunting 4
maple syrup 5

---

66. What kinds of birds and animals lived in the area near the drain before the project? ____________________

---

67. Did the drain cause the kinds or numbers of wildlife to change?

No (skip to Q.69) 1
Yes 2

---

68. What changes have you noticed? ____________________

---

69. Did hunters use the area along the drain before the project?

No (skip to Q 72) 1
Yes 2

No.________

70. What did they hunt? ________________________________

____

71. How many hunters used the area each year? ________ No.

72. Do hunters use the area along the drain now?

No (skip to Q. 75)	1
Yes	2

73. How many hunters use the area along the drain now? __________ annually.

74. What do they hunt? ________________________________

____

75. Are there or have there ever been any fish in the drain?

No (skip to Q. 84)	1
Yes	2

76. What kinds of fish were in the drain before the project?

None (skip to Q. 81) ..	0
Specify ______________	1

77. Did the work on the drain cause the kinds of fish to change?

No	1
Specify ______________	2

78. Did fishermen use the drain before the project?

No (skip to Q. 81)	1
Yes	2

79. What did they catch? ________________________________

____

80. How many fishermen used the drain each year? _______ no.

81. Do fishermen use the area along the drain now?

No (skip to Q. 84)	1
Yes	2

No.__________

82. How many fishermen use the area along the drain now? _________ annually

83. What do they fish for? ____

84. Did beaver, muskrat, or coons live in the area near the drain before the project?

No (skip to Q. 86)	1
Yes	2

85. Were beaver, muskrat, or coons trapped prior to the drainage project?

No	1
Yes	2

86. Do beaver, muskrat, or coons live near the drain now?

No (skip to Q. 89)	1
Yes	2

87. Are beaver, muskrat, or coons trapped now in or near the drain?

No	1
Yes	2

88. What is the comparative amount of trapping before and following the drainage project?

no trapping	0
no difference	1
more before drainage ..	2
more after drainage ...	3

89. Have beavers caused drainage problems in this area?

No	1
Yes	2

90. How serious are these problems? ____

____

91. Have cattle or other animals caused damage to the drain? ______________

No	1
Yes	2

No.________

92. Are there any man-made barriers which adversely affect drainage or prevent you from draining your farm? (Probe)

No (skip to Q.94) 1
Yes 2

93. Explain ____

94. Did the drain make it necessary to buy or build new equipment, buildings, bridges, fences, pumps, etc.?

No (skip to Q.96) 1
Yes 2

95. Would you tell me what changes were necessary?

Item	Cost	Reason for Purchase

96. Do you spend more or less time on average working the farm since completion of the drain?

No change (skip to Q.98). 0
Less 1
More 2

97. How many more/less days per year?

on-farm:* __________days/year
off-farm: __________days/year

* + for more, - for less

98. Do you have an off-farm job?

No (skip to Q.104) 1
Yes 2

99. What kind of job? ____

100. Has the time spent in your off-farm job changed since completion of the drainage project?

No (skip to Q.104) 1
Yes 2

No.________

101. How many more days per year

on-farm: ________ days/year

off-farm: ________ days/year?

---

102. Was this change in off-farm work made possible or made necessary by the drainage project?

No (skip to Q. 104) ... 1
Yes 2

---

103. Explain ____

____

---

104. Do you hire any labour for this farm?

No 1
Yes 2

---

105. Since completion of the drainage project has the amount of labour you hire changed?

No (skip to Q. 109) ... 1
Yes 2

---

106. How large has the labour change been?

days/year more ________

days/year less ________

---

107. Was this change in farm labour made possible or made necessary by the drainage project?

No (skip to Q. 109) ... 1
Yes 2

---

108. Explain ____

____

---

109. Have you changed the size of your farm since completion of the drainage project?

No (skip to Q. 113) ... 1
Yes 2

No.__________

110. By how many acres was the farm

Increased?__________acres

Decreased?__________acre

111. Was this change in farm size made possible or made necessary by the drainage project?

No (skip to Q.113) 1
Yes 2

112. Explain ____

113. Has the amount of feed, for example grain or hay, which you buy or sell changed since completion of the drainage project?

No (skip to Q.117) 1
Yes 2

114. By how much have your feed sales or purchases

	item*	Change in units/year	Annual value of change
Increased			
Decreased			

* purchase = (P)
Sale = (S)

115. Was this change in feed sales made possible, or made necessary, by the drainage project?

No (skip to Q.117) 1
Yes 2

116. Explain ____

No.________

117. Has there been a change, related to the drain, in the number, quality, or products of the following livestock and fowl?

Livestock/fowl	no change	how much more (no.)	how much less (no.)	Reasons for change
beef cattle				
milk cows				
milk production				
milk quota with Ont. Milk Marketing Board				
pigs				
chickens				
eggs				
turkeys				
others (specify)				

118. How much do you feel that your farm income has changed because of the drainage project?

No change 0
less than 1% 1
1-5% 2
6-10% 3
10% 4

119. Did you sign the petition for the drain?

No 1
Yes 2

120. Would you have supported the drain construction without the government subsidy of ______% ?

don't know 0
no 1
yes 2

No.________

121. What benefits did you expect from the drain? ____________________

____

122. Was it your intention to install field tile drainage after completion of the project?

No	1
Yes	2

123. Do you think that increased crop and livestock yields related to the drainage project will pay for it?

never	0
in 1 year	1
in 2-5 years	2
in 6-10 years	3
in more than 10 years .	4
specify years ________	

124. At the time of project approval were you?

neutral or undecided .... about the project ...	0
in favor of the project..	1
opposed to the project...	2

125. Now are you

neutral or indifferent...	0
in favor of the project..	1
opposed to the project...	2

126. Would you be sympathetic concerning maintenance of the drain when it is required?

don't know	0
no	1
yes	2

127. Have you any additional comments concerning land drainage projects?

____

No. ________

Interviewer ____________________

Date ____________________

Drain No. ____________________

Date od drainage project ____________________

Type of drainage project ____________________

Acreage assessed ____________ Total acreage ____________

	Engineer's estimate	Actual
Assessment (outlet)		
Assessment (benefit)		
Total Cost		

Dominant soil series ____________________

Operator's age ____________________

No. of years on property ____________

Future plans ____________________